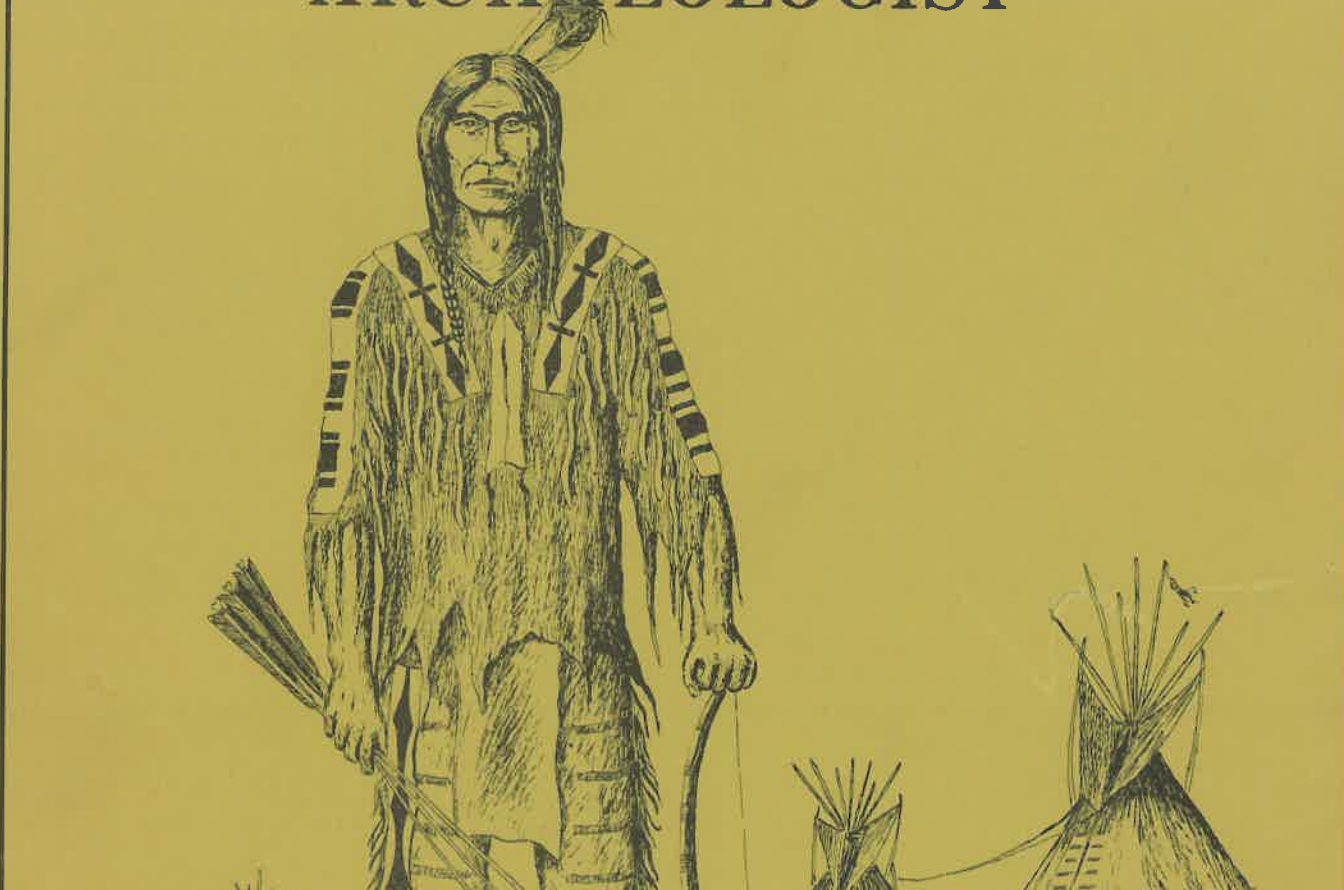
THE WYOMING ARCHAEOLOGIST



JULY 1972

VOL. ~~XV~~ NO. 2

WYOMING ARCHAEOLOGICAL SOCIETY

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APPENDIX A

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APPENDIX B

THE WYOMING ARCHAEOLOGIST is published quarterly by the Wyoming State Archaeological Society, Grant H. Willson, Editor. Address manuscripts and news items for publication to: The Editor, 1915 East 15th Street, Cheyenne, Wyoming 82001.

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APPENDIX C

JULY, 1972 ISSUE CONTENTS

EDITOR'S NOTES

Beating the drum for the Archaeological Foundation at the June 16th Mining Convention in Jackson, were: Baskett, Jensen, and Albanese. Other contacts are being made but this effort cannot be done by only a few. Each Chapter must canvass its own area and make the presentations. Each Chapter should form an effective team, make a list of likely contributors as suggested by their Membership, then make appointments and present the Foundation Story.

Be prepared by questions as to history of the Society, reason for its being, why preserve antiquities? What value do they have? etc. A short slide program would also help and this we should prepare. If each Chapter would pick ten to fifteen of the best slides depicting their Chapter's activities and bring them to the Summer Meeting, we could duplicate these and prepare such a program.

Will you help?

WYOMING
ARCHAEOLOGICAL SOCIETY, INC.

July 5, 1972

Dear Fellow Members:

The Summer Meeting will be August 5th and 6th, with headquarters at Shoshoni. Saturday's plan includes a trip to Castle Gardens, approximately 17 miles south of Moneta via the Linn Ranch Road.

The caravan will depart from the Shoshoni City Park at 1:30 p.m., and will be heading south from Moneta about 2:15 p.m. The Saturday evening convocation will be held at the summit of the Screaming Mimi in Thermopolis. This should satisfy the skinny dipping majority after the warm trip to Castle Gardens.

On Sunday morning a short briefing session will be held prior to start of trek at 9:00 a.m. The morning will be spent in the historic Copper Mountain area with a side trip to Lysite to the Jensen's oasis for lunch. Their log cabin summer home is a real historical gem in a lovely setting. Sunday afternoon's trek will be concluded at 4:30 p.m., north of Arminto.

Each person should provide their own lunch and vehicles with sufficient clearance to travel rutted roads are necessary. However, there will be sufficient room with other members for those who do not have the proper vehicles. Reservations should be made in Shoshoni as soon as possible or could be made at Thermopolis.

Dr. Frison is busy with the University's archaeological crews at South Pass City, and a larger crew will be at the Vore Site near Beulah until mid July.

Helen Schuster will soon be in the Lander area for Petroglyph Survey.

I would like to know which Chapter will be first to achieve 100% in contributions to the Archaeological Foundation. Could we please have a report of the percentage from each Chapter at this meeting?

That's all the news for now. See you in Shoshoni.

Grant Willson

DR. MULLOY TO EASTER ISLAND

April 27, 1972 -- Blowing snow, knife-edged winds in April often prompt a Wyomingite to dream of a far away island in the South Pasific where the sun always shines.

This dream is a reality for William Mulloy, professor of anthropology at the University of Wyoming, as this summer he will make his 17th archaeological expedition to Easter Island.

Mulloy is the director of the $12,492 National Endowment for the Humanities grant recently awarded UW for the continued support of archaeological research and monument restoration on Easter Island.

The Easter Island project is also supported by the International Fund for Monuments Inc., New York and the Republic of Chile.

Easter Island, a territory of Chile, is unique because the early inhabitants developed an advanced culture with little influence from the outside world.

Pitcairn, the nearest island lies 1180 miles to the east. Easter Island seems to have been outside the prehistoric pattern of systematic two-way Polynesian sea contacts.

The most likely source of population was lost seafaring wanderers from Marquesas Islands. The population of Polynesians on Easter Island once estimated at 20,000 has dwindled to 1400.

Archaeological evidence indicates there was an early highly developed culture which is rare among primitive peoples who have lived in physical isolation.

Mulloy's work this summer will be at Tahai, which is believed to be the largest spectacular example of prehistoric architectural achievement to be found in Polynesia. Archaeologists have been working at Tahai for the last four years.

Mulloy will be directing the restoration of Ahu Mahanua. His crew will consist of 25 islanders including a native photographer trained on a previous expedition by Herb Pownall, media specialist of the UW Agricultural Extension service.

The name, Easter Island, usually conjures the image of huge sober-faced stone statues. Mulloy estimates there are over a thousand of these statues called moai on the island. The largest one excavated so far weighed over 80 tons.

The statues were carved in a stone quarry on the slopes of the large volcanic cone, Rano Raraku, transported on prepared roads and erected on the walls of the more than 300 open air religious altars. The largest of these altars, called ahu, are over 200 yards long. (University of Wyoming News Service)

Most of the monuments were destroyed during prehistoric warfare and are covered by rubble. The sites are even difficult to recognize and restore by experienced archaeologists.

Other architectural achievements on Easter Island include villages, towers, caves lined with masonry, living rock sculpture and walled terraces. They also possessed a written language which was unrelated to any other script.

The studies and restoration of the monuments are important in the interest of higher learning and to the cultural, economic and social future of the islanders.

THE TOOL AND PROJECTILE POINT ASSEMBLAGES

The tool assemblage was contained in a context interpreted as one highly specialized in butchering. It is reasonably and obviously assumed further that the tool assemblage recovered represents the means of accomplishment of the butchering process. The tool assemblage is composed, to a large extent, of materials derived from the animals killed and from deposits at the site. Only the chipped stone tools are from materials brought any appreciable distance. Compared to many other tool assemblages, this one demonstrates a lack of concern in manufacture, but is no less functional than any other, as a result. Some bone tools are obvious while others can be identified as tools only by microscopic analysis. It is obvious that certain kinds of edges formed by breaks on bones were being chosen and, conversely, they were probably breaking bones deliberately in some instances to produce these edges.

A large share of butchering consisted of chopping loose, breaking off, or crushing muscle attachments and subsequently stripping out the muscles. The former processes were accomplished by a large number of crude but functional tools made from a variety of different boulders and cobbles found in deposits in the immediate site. One type of tool used in chopping was made by breaking an elongated boulder diagonally so as to provide a hand hold on one end and a chopping edge or point on the other. Occasionally, chopping tools were flattened boulders that bear evidence of a working edge shaped by a few large percussion flakes. Other boulders were used as hammerstones and were selected for shape. Larger boulders were probably used as anvil stones since it appears to have been common practice to break certain bones by striking them against or over an anvil stone. Others were broken by laying them on an anvil and hitting them with a hammerstone.

Chipped stone tools represent a variety of different kinds of cherts, quartzites, and metamorphosed shales available within a radius of about thirty miles. Most of these, as for the bone tools, demonstrate a greater concern with function than with esthetic values. Most of those recovered were either worn out or broken and no longer functional. Tool sharpening flakes from both percussion and pressure methods occurred throughout the bone deposits and provide additional information on numbers of chipped stone tools used and methods of sharpening and use.

The Bone Tool Assemblage

A large number of bone tools utilized either deliberate or fortuitous breaks on different bison bones. All bear evidence of use in the form of wear striations and different degrees of polish on the working edge (See Table 3). Some bear evidence of light to moderate grinding to give definite shapes to the working edges while others utilize a break with no modification.

The largest group includes bison rib tools on which the proximal articular end

	HANDLE END				WORKING EDGE																				
					PLAN VIEW					CROSS SECTION		LOCATION								PREPARATION				WEAR	
BONE USED	proximal	middle	fragment of middle	distal	pointed	rounded	transverse	long curve	scalloped	tapered	square	anterior	posterior	lateral	medial	dorsal	ventral	distal on all sides	unident.	original break	grinding	percussion	percussion grinding	parallel to long axis	angle to long axis
RIB	90	88		6	123	26	21	14		166	18	26	23	62	73					110	69	2	3	181	3
DORSAL SPINE		9			3	5	1			7	2	3		6						8	1			9	
METAPODIAL	33			35	14	33	9	12		36	32	22	22	10	14					63	5			59	9
TIBIA	3	3		18	7	7	4	6		14	10	3	9	6	6					21	3			19	5
FEMUR	3	3		1	3		1		3	5	2	2	1	1	3					4	3			6	1
HUMERUS	5	3		4	3	2		2	5	11	1	2	2	5	4					12				10	2
RADIUS	2			6	4	1	1	2		6	2	2	2		4					8				5	3
ULNA	8	2			10					10					2			8		6	4			10	
ILLIUM				5		3	1	1		5						2	3			5				5	
ISCHIUM	3				1	1	1			3					3					3				3	
ASCENDING RAMUS	6	2				3	5			2	6		1	1	2		4			8				8	
MANDIBLE DIASTEMA	1			5	3	1		2		5	1			1	1	2	2			5	1			4	2
SCAPULA	1			1	1	1				2			1	1						1	1			2	
CALCANEUS				1		1				1				1						1				1	
PREMAXILLARY	1						1			1				1						1				1	
LONG BONE FRAGMENT			44		16	12	6	7	3	32	12								44	32	12			39	5
TOOLS FROM ARTICULATED BONES																									
ARTICULATION	WORKING EDGE																								
HUM.-RAD.-ULNA	ULNA	HUM.and RAD.							1	1				1						1				1	
HUM.-RAD.-ULNA	HUMERUS	ULNAand RAD.						1		1		1								1					1
HUM.-RAD.-ULNA	HUMERUS	ULNAand RAD.							1	1				1						1				1	
HUMERUS-RADIUS	HUMERUS	DISTAL RAD.							1	1				1						1				1	
RADIUS-ULNA	RADIUS	PROX. RAD.						1		1			1							1					1
TIBIA-METATAR.	TIBIA	DIST. METAT.						1		1			1							1					1
TOTALS	160	110	44	84	188	96	51	49	14	312	86	61	62	98	112	4	9	8	44	294	99	2	3	365	33

Table 3 - Bone tools made either from deliberate or fortitious breaks on various bison bones.

was used as a handle. Working edges present a range of variation from nearly straight to rounded or pointed. They may utilize a long portion of the rib or the working point or edge may be close to the articular end and may be formed on the medial or lateral side or the anterior or posterior edge (Fig. 17a-aa). In addition, the same kinds of working edges were formed on sections of ribs (Figs. 17bb-dd, 20a-k). All ribs from number 1 through 14 were utilized. A less frequent rib tool type was a range of deliberately-formed, parallel-sided points with blunt tips formed on the lateral rib surfaces (Fig. 17ee-hh). Wear striations on all of these rib tools are usually nearly parallel to the longitudinal axis of the ribs. A different kind of use on rib tools is found on at least five tools on which the working edge is a fortuitously-formed, longitudinal or diagonal split with wear striations at nearly right angles to the working edge, suggesting a tool analogous to and use similar to that of a dull steel knife.

Another different type of rib scraping tool utilized only ribs numbers 10 through 13, which were the only ones that were of the required shape. The rib was broken transversely just distal to the neck and the medial side was used as the working edge for a scraping tool, taking advantage of the rather sharp bend in the rib at this point. This was a tool that was pulled toward the operator on the scraping strokes. Another class of rib tools have blunt, rounded points and are probably knapping tools (Fig. 19f-i,m), although at least two of these were ground to blunt points and the wear is a high polish unlike the ordinary use marks on knapping tools. They may have had other functions besides knapping. A number of small rib splinters have worn, sharp points formed on one end but no other modification (Fig. 20e-k).

Other bones were used to a much lesser extent for the same purposes. Pieces of long bone, such as radii (Fig. 19j) and ulnae (Fig. 19k,l), were probably knapping tools; and a single knapping tool of elk antler was made by cutting longitudinal grooves into the heavy beam of the antler and removing a strip which was later ground to shape (Fig. 19n). A single knapping tool (Fig. 19m) was made from the anterior edge of a number one rib. Pieces of dorsal spines were used with pointed, rounded and straight working edges similar to the rib tools. A single tool made from a number six or seven rib has the medial surface ground down so that the edge formed by the junction of the medial and anterior sides is quite sharp. This tool is reminiscent of beaming tools found in other contexts (Frison 1967: 79). The lack of beaming tools and end scrapers is strongly indicative that hide work was done elsewhere.

Heavier bones were used extensively as tools also, and most common were metatarsals. Both proximal and distal ends were used as handles and a wide variety of different breaks across the diaphyses were utilized as working edges. Some are pointed, while others vary from thin tapered edges functionally similar to the common metatarsal flesher, to square blunt edges. All utilize the breaks with little or no grinding to prepare a working edge (Fig. 18a-i). Metacarpals were also utilized quite extensively and present the same range of tools as the metatarsals (Fig. 18j-r). Wear striations usually appear at nearly right angles to the breaks utilized as working edges.

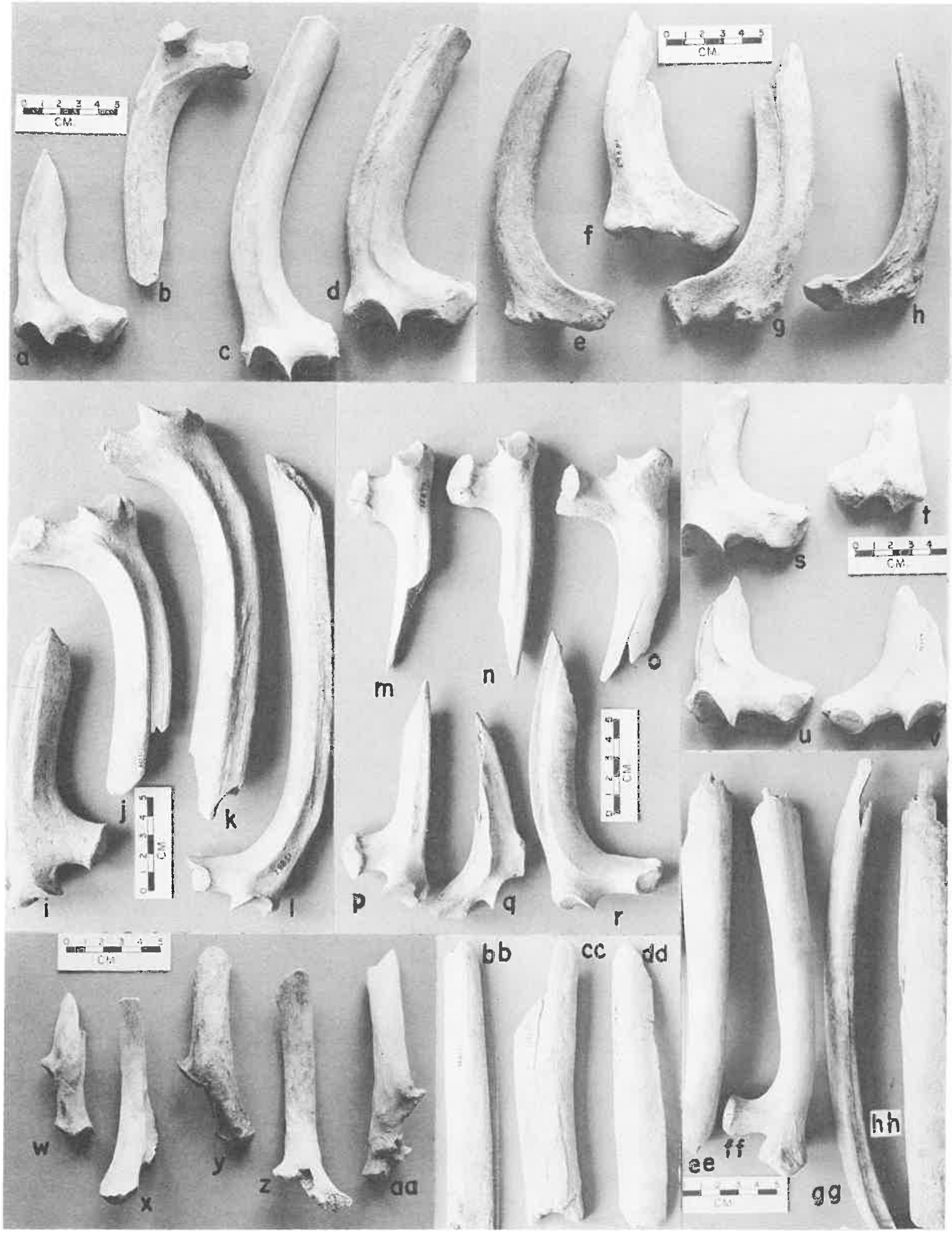

Figure 17 - Rib Tools.

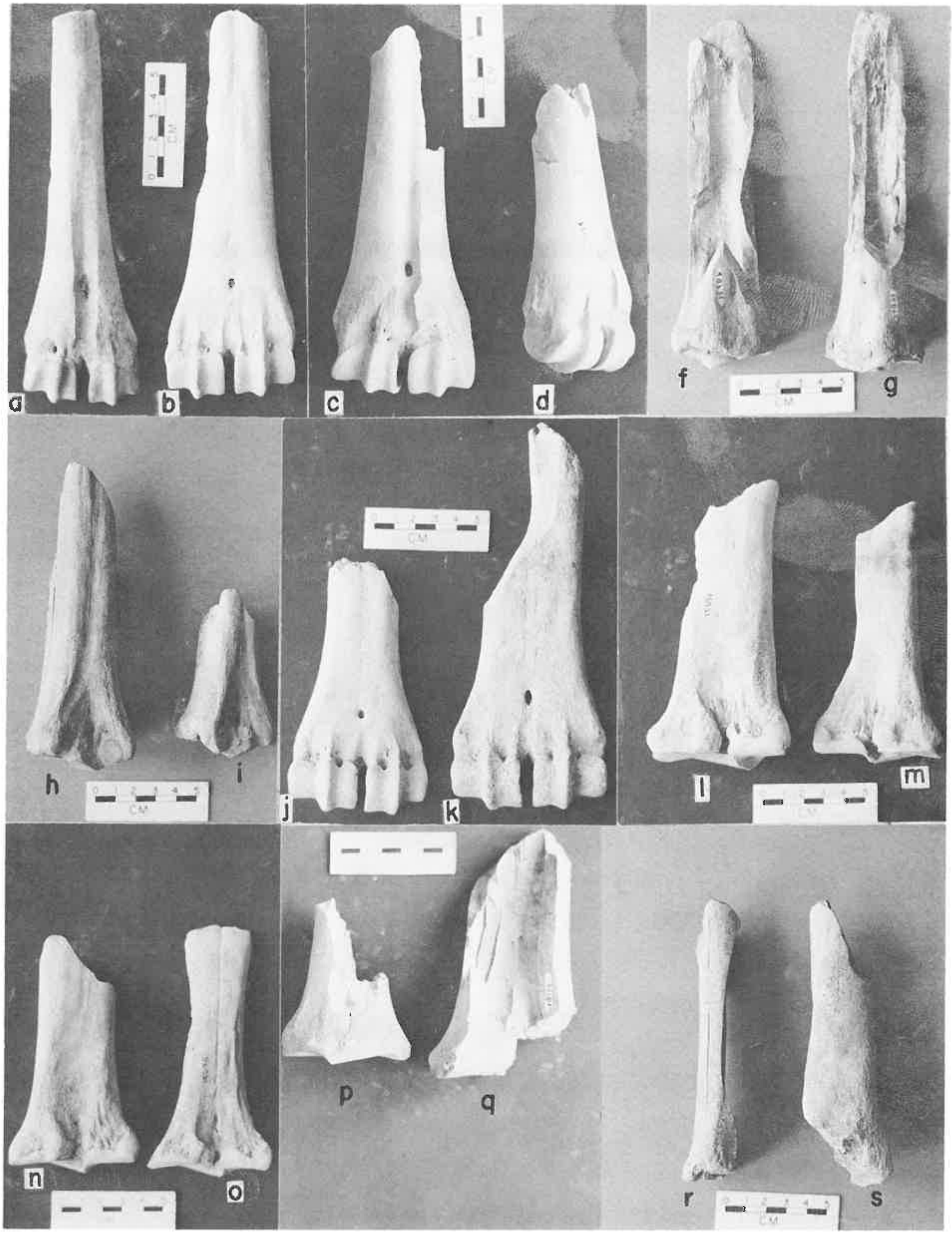

Figure 18 - Metatarsal tools (a-i), metacarpal tools (j-r), and a femure tool (s).

Other bones were used with less frequency. An interesting variation is a section of a femur (Fig. 20v) which has one corner ground to shape for a working edge, and upon which fine wear striations cover the entire working surface, suggesting use against a soft, resilient substance possibly in the skinning process. Less common were humerii which utilized the distal end as a handle and transverse breaks as working edges. All bear a high polish from use. Another use of small humerii was to break off the proximal articular end in such a way that the edges have a scalloped appearance. This end was used as a scraping tool with wear striations and polish parallel to the longitudinal axis of the bone (Fig. 19a,c). Several sections of heavy long bone have blunt, rounded working edges formed by varying amounts of grinding and subsequent wear striations and polish from use (Fig.20 l-p).

Tibiae were used quite extensively as tools, usually employing the distal end as a handle and tapered or square breaks as working edges (Fig. 20q-s). Next most common utilization of the tibia were central portions with fortuitously formed edges bearing evidence of a deliberate shaping by light grinding and subsequent wear markes. Some of the largest tools are tibiae, with the proximal articular end intact and used as a handle. Prepared and well worn working edges are opposite (Fig. 22d,e). Two tibiae have the proximal articlar ends chopped off squarely. The flat sides bear evidence of scraping use and are reminiscent of the humerii scrapers but lack the scalloped working edges.

Radii were less frequently used and the few recovered bear evidence of the same kinds of use as the metacarpals, metatarsals, and tibiae. Besides knapping tools, at least five ulnae were used as picks or sharp-pointed gouging tools, with the olecranon as a handle.

Femora were occasionally used as tools. The most common method (five specimens) was to use the head as a handle and transverse distal breaks as blunt scraping edges. One femur tool has a working edge in the form of a projection that is worn smooth from use (Fig. 18s). Two femora were made into scraping tools by breaking the distal articular end to form a scalloped edge. They were utilized in the same manner as described for small humerii (Fig. 19b,d). Another femur tool has a well-worn, rounded working edge (Fig. 19e).

Mandibles were often broken from the vicinity of the third molar across to the ventral border. The edges resulting from these breaks were utilized as working edges with the ascending ramus serving as a handle (Fig. 21). Distal ends of mandibles were used in various ways. One was a knapping tool; others pointed or blunt-edged tools utilizing the diastema and the symphysis as a handle and fortutitous breaks across the premolar area as working edges. They appear functionally similar to a number of rib tools already described. At least two right mandibles suggest possible use as choppers, using the diastema as a handle. The cheek teeth bear evidence of extreme wear and breakage believed to be the result of use as a chopping tool (Fig. 19o).

Miscellaneous bone tools include two broken parts of illii and two ischii which bear evidence of scraping use on edges formed by breaks. In both cases, good handles are provided rather fortuitously by the configuration of the remainder of the bone (Fig. 20t,u). One antelope metacarpal, ground to an unusual shape (Fig. 20w), may have been a tool for gouging marrow out of bones. One Canis sp. humerus was used as a sharp pointed tool with the distal end as the handle.

At least two large sections of heavy long bone, with fortuitously rather blunt knife-like edges with the wear striations and polish on both sides and at right angles to the working edge, suggest use analogous to that of a dull steel knife. They may have been some sort of skinning tools. Several large bone tools were made from articulated sections. One (Fig. 22f) has a worn working edge formed on a transverse break of a tibia which was still articulated to the tarsals. The tibial tarsal and metatarsal served as a handle. Three specimens were articulated humerus-radius-ulna units. One (Fig. 22a) has a well-worn, rounded working edge on a diagonal break across the humerii. The radius-ulna and olecranon were used as a handle. Another (Fig. 22b) has the working edge on both side of a transverse break across the olecranon with the radius-ulna and humerus the handle. The third has the radius-ulna broken diagonally so that the end of the ulna forms a blunt point which bears wear striations and polish. The handle was the broken humerus and ulna (Fig. 22c). A number of other tools may also have been originally articulated and later separated.

Use of Bone Tools

The bone tool assemblage is large and includes a number of different bones (Table 3), but instead of a large number of actual tool types, most represent a wide range of variation of a single type. This type includes working edges on bones provided with suitable handles and used in directions so that wear was mostly at right angles to the working edge. They were probably used for a variety of different purposes such as removing flesh from surfaces, bone marrow from the interior of bones, and hides from carcasses. It seems likely that skinning in this context was done by more than one person. It could be done quite efficiently with one or two persons pulling on a hide and someone else using a heavy, blunt edged tool to loosen it. Upon initial analysis, there is a feeling of wide diversity of bone tools of this type but actually a working edge, whether it is on a broken mandible, femur, radius, humerus, metacarpal, metatarsal, rib, illium, or ischium, all demonstrate a homogeneous group upon a careful functional analysis. A sharper pointed tool was probably needed to get under muscle attachments, a less pointed tool would be better for scraping meat from fossae such as on the lateral side of the scapula, and wide, straighter edges would have been better for larger bone areas such as the medial side of the scapula and the pelvis. Removing marrow from bones also required a varied range of working edges.

Scraping tools, used by pulling toward the person, are in a definite minority and could even represent individual preference. They would have performed the same operations as other scraping tools only in a different direction of use.

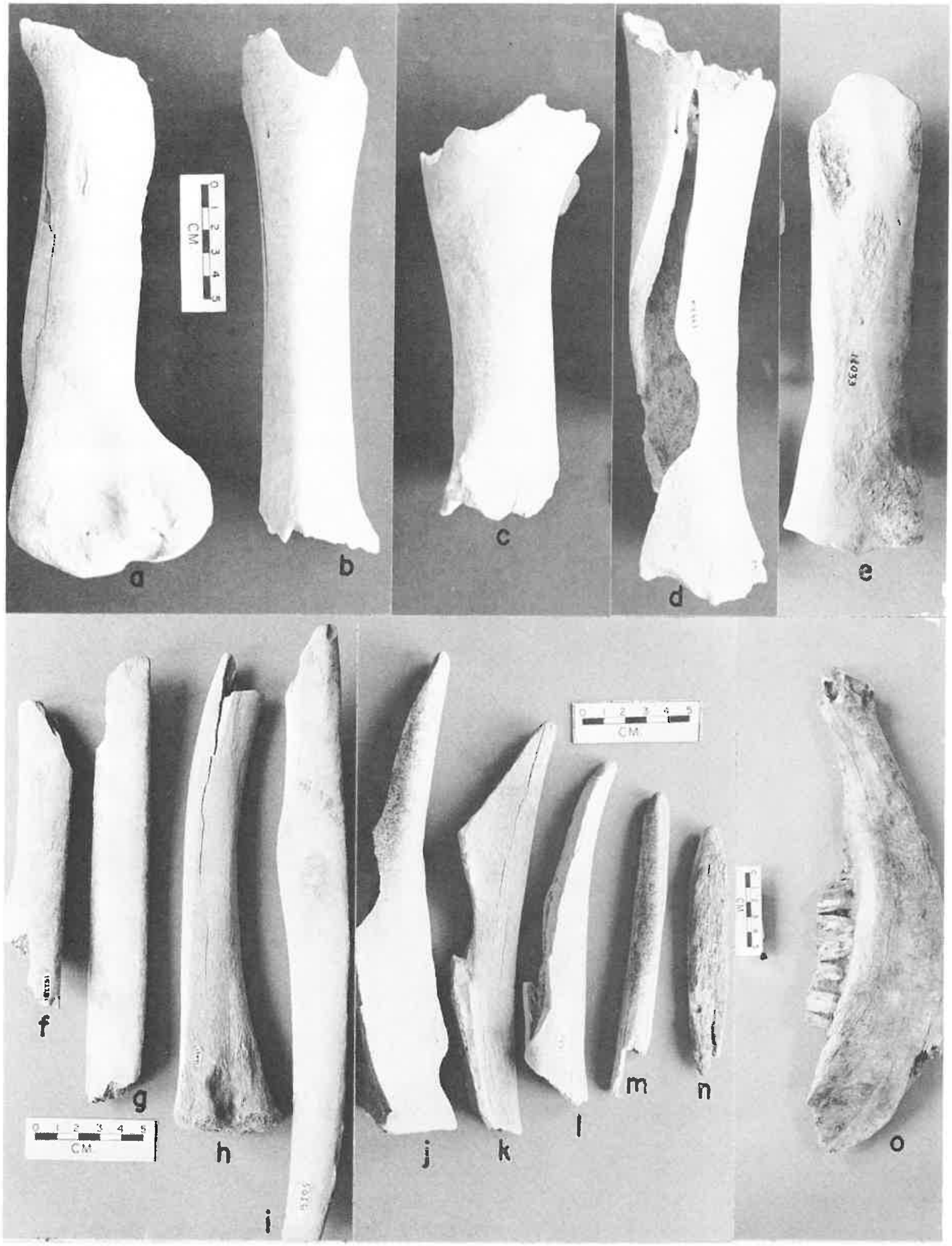

Figure 19 - Scalloped-edged scraping tools (a-d), femur scraping tool (e), rib, ulna, and radius knapping tools (f-m), elk antler knapping tool (n), and a mandible chopper (o).

The tools described that were fragments of heavy, flat sections of long bone (Fig. 20v), usually with relatively sharp edges and bearing wear striations on both sides at right angles or nearly so to the working edges, are difficult to explain unless the tool was used in a way analogous to that of a steel knife for skinning purposes. A good deal of skinning can be accomplished with a blunt tool once the necessary slits are made in the hide. A person who has done a good deal of skinning often uses the butt of the knife handle to loosen a hide from the carcass as well as the blade. The bone tool assemblage is somewhat reminiscent of that obtained by Kehoe (1967) at the Boarding School Bison Drive Site. The difficulty of recognizing many bone tools without careful analysis leaves a strong suggestion that other kill and butchering sites may contain significant numbers of unrecognized tools.

The Stone Tool Assemblage

Hammerstones, Choppers and Anvil Stones

These tools were obtained from material that eroded from a level of smoothed boulders and cobbles on the flat by the jump-off. Little modification appears although there is a careful selection of tools as indicated by functional categories represented. With the exception of hammerstones, the boulders were split and shaped by percussion to provide a proper working edge and a handhold. Size of the stones varies from 11 ounces to as much as seven pounds but most are from 3.75 to 4.75 pounds. Weight was an important factor in tools of this nature. A critical mass of stone is necessary to break, chop, and crush bone properly, especially with tools with edges that are blunt compared to a steel axe.

Hammerstones vary from ovoid or nearly round in outline form, 10.5 cm. to 15.5 cm. maximum diameter and 5.7 cm. to 6.8 cm. thick. Various parts of the perimeter bear evidence of hammerstone use (Fig. 23d-e). Another common form is more elongated (14 cm. to 24.5 cm.) with cross sections nearly round to ovoid and even vaguely rectangular in cross section . Both ends usually bear hammerstone use (Fig. 23f). A variation of this includes those with one end removed by percussion. The resulting sharp edge bears evidence of use around its circumference (Fig. 23i).

Another type of tool, made from water-worn boulders, includes a range of variation of working edges. Large spalls from a side of a large boulder provided a broad, relatively sharp chopping edge (Fig. 23g) and a handhold opposite. Spalling from one end of smaller cobbles provided working edges (Fig. 23h). Some were made by series of large percussion flakes to form a crudely flaked working edge (Fig. 23a). A variation of this includes a large number of tools that are spalled to form a pointed working edge (Fig. 23b). Many are composite tools with each end having a functionally different point or edge (Fig. 23c).

A total of 16 large boulders weighing as much as 15 to 20 pounds suggest use as anvils and some bear evidence of pounding use. Certainly the use of such stones best

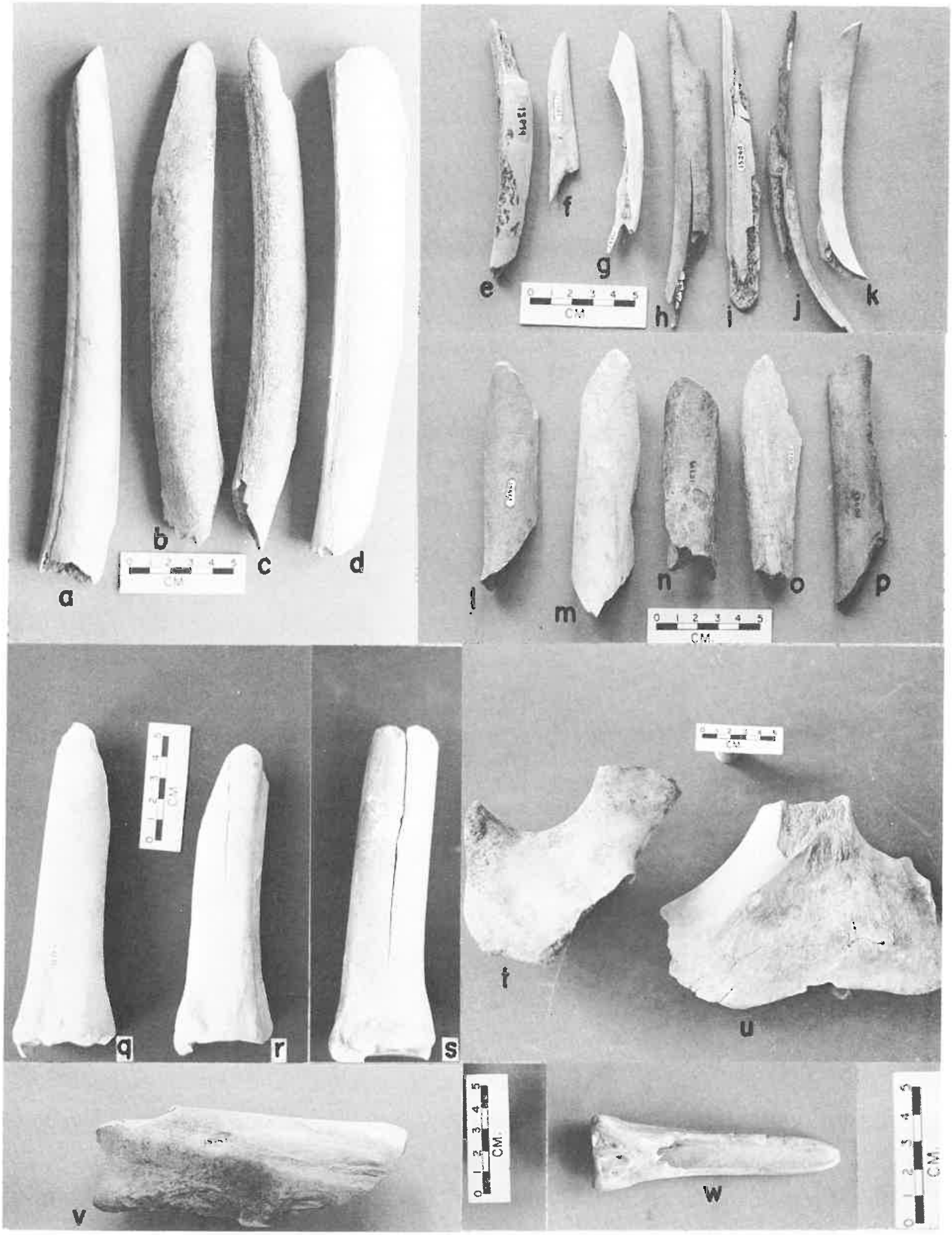

Figure 20 - Rib tools (a-k), tools made from long bone fragments (1-p,v), tibia tools (q-s), scraping tools made from broken isium (t) and ilium (u), and a tool made from antelope metacarpal (w).

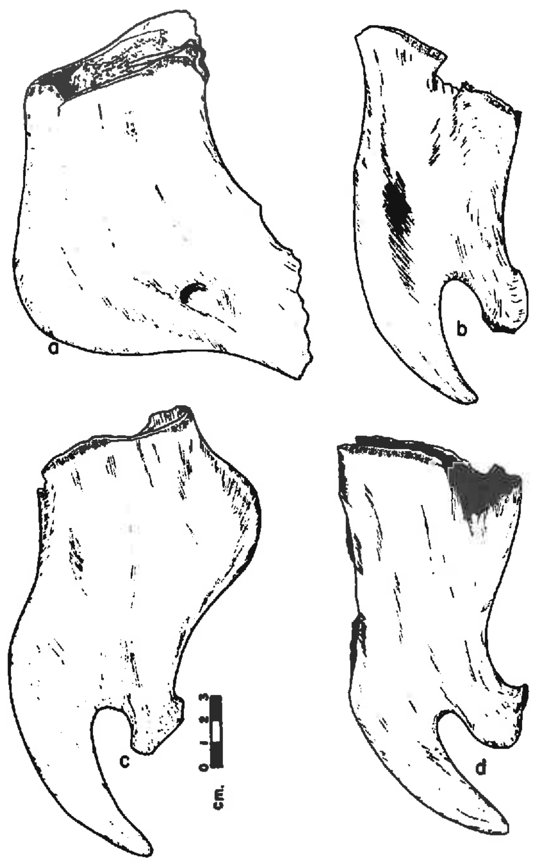

Figure 4 - Bison Mandible Scraping Tools

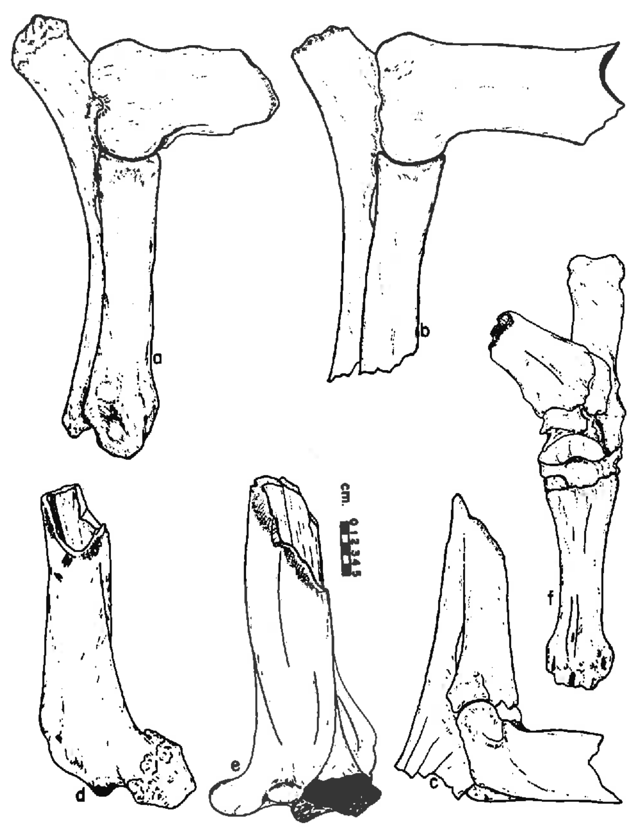

Figure 22 - Articulated Humerus and Radius-Ulna Tools (a-c), Tibia Tools (d-c), and Articulated Rear Leg Tool (f).

explains part of the butchering process. Chopping of muscle attachments such as as the olecranon and tuber calcis, crushing and splitting of radii and ulnae and other large bones, chopping loose the articular ends of humerii, femora and tibiae, and other operations can best be explained as the result of placing the bone on an anvil stone as a base for pounding or chopping.

In summary, a total of 82 of these rather crude stone tools were recovered and they were important in the butchering process. The sharp edged and pointed tools were used to chop loose muscle attachments such as the tuberosities of the humerus, the greater trochanter of the femur, the tuber coxae, the tuber ischii, and to remove the medial ridge of the trochlea in order to gain access to the patella. They would also have been used to break and chop ribs and vertebrae and break open brain cavities and split skulls. The blunt hammerstone tools were used to break bones, to obtain marrow and perform rather specialized uses, such as breaking the temporal condyles and the mandibles. Some of these may also have been used as an aid in skinning processes since a blunt-edged tool can be used effectively to help loosen a hide from the carcass.

The Chipped Stone Tool Assemblage

Cutting edges provided by chipped stone tools were necessary to the butchering process for a number of operations. These include cutting open the hides at necessary places, skinning, cutting ligaments, and muscle attachments. The use of such tools can be interpreted from marks left on the bones. These marks are the result of the sharp points on the edges of chipped stone tools. During use of such tools, it is common to repeat a number of strokes in a sawing manner which left distinctive grooves in the bone.

The chipped stone tools are mostly large percussion flakes with the working edge or edges usually following the configuration of the flake. Working edges may be concave, straight, or convex, or a combination of all three on the same tool. On most, the original bulbs of percussion are intact and they apparently were driven from large biface cores. The flat face of the percussion flake was usually preserved although the retouch may be unilateral or bilateral or both (Fig. 23 j-k, j'-k'). Nearly all of the tools found were broken, worn out, or for some reason no longer functional. One exception (Fig. 23j) still appears in usable condition.

Tool resharpening was done mostly by percussion with lesser amounts by pressure. It is obvious that all possible use was obtained from these tools before they were discarded. Nothing suggests that these were expressions of the stone-flakers art, but were every bit as functional as ones that were. They include bifaces, unifaces, and retouched flakes which in many cases are rather arbitrary divisions. Three biface tools were probably hafted. One of these (Fig. 23m) bears evidence of use in the form of wear striations and polish on one end parallel to the cutting edge. The other end has a longer taper and was probably the end that was hafted. Continued resharpening finally rendered it unusable. A similar tool

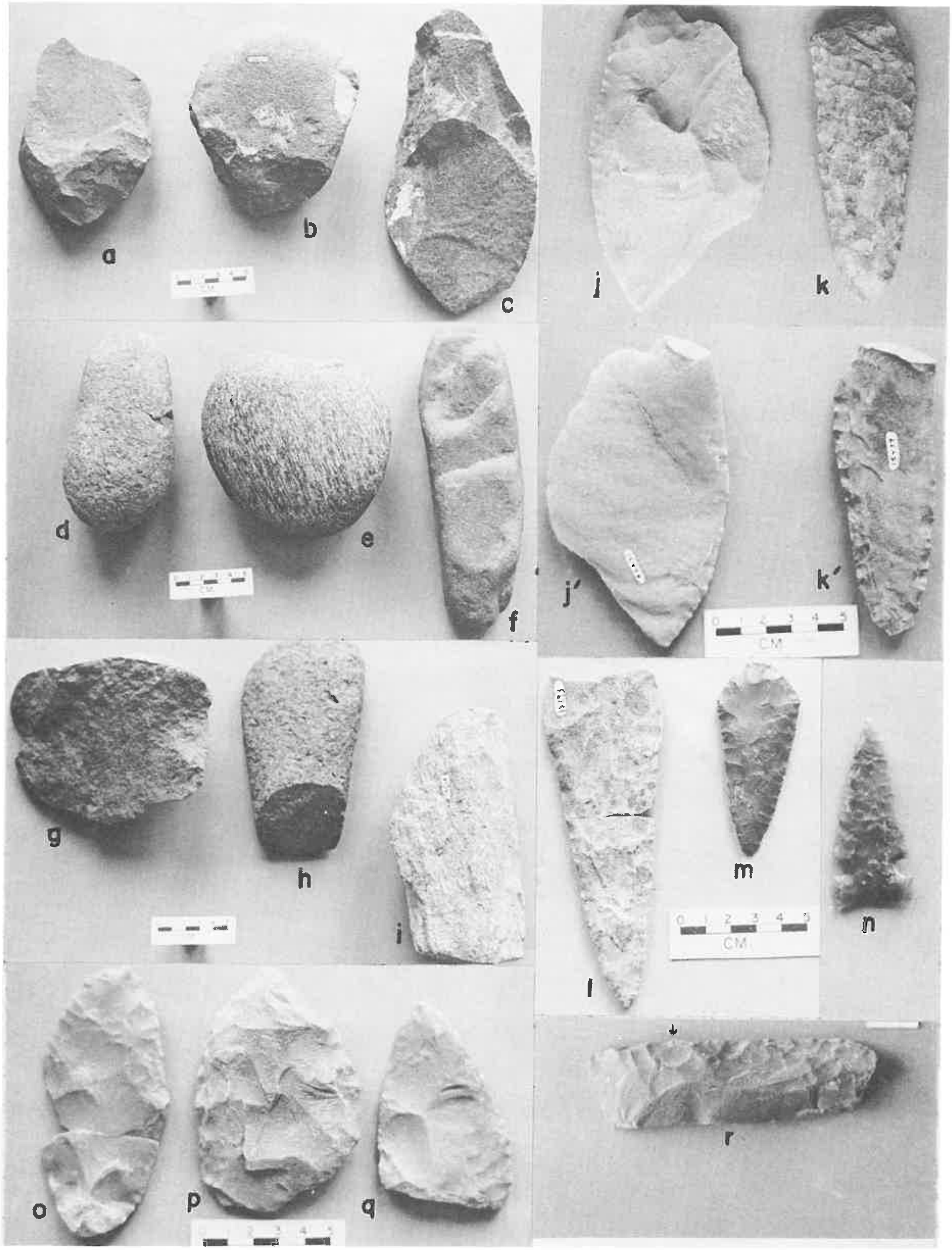

Figure 23 - Hammerstones and choppers (a-i), knives (j-q) and side scraper with sharpening flake replaced in flake scar (r).

(Fig. 23l) was broken and discarded. Another tool suggests a large projectile point in outline form, but blade edges bear evidence of use suggesting it was a knife. It was undoubtedly hafted (Fig. 23n). Three nearly-complete bifaces were used and resharpened to a worn out condition (Fig. 23o-q). In outline form they are ovoid or pointed on one end and rounded on the other. They are lenticular in cross section. Four other fragments are parts of similar tools. One biface, flaked to form one flat side, has a steeply-flaked edge on the opposite side and is functionally a side scraper. Variations in the side scraper category are scraping tools beveled on alternate edges so that in transverse cross section they form a parallelogram.

Only four plano-convex end scrapers were recovered, all of which are typical with transverse rounded working edges opposite the bulb of percussion. Two are broken in a manner suggesting they were hafted, which is further indicated by polish on one over the median ridge between flake scars on the back of the tool. This was probably caused by rubbing against the haft bindings.

The retouched flake category includes at least 32 flakes, used as cutting and scraping tools, which utilized fortuitously formed edges. Wear is usually in the form of use flake scars with an occasional deliberate percussion or pressure retouch.

All of these tools are similar to those in a number of other local mass-butchering contexts. The working edges of the tools fall into two separate categories in terms of edge angles. It appears there are functional reasons for this and probably the difference is between cutting and scraping. Cutting edges cluster around a value of 37° to 42° while scraping edges cluster around 48° to 53° and form a bimodal distribution (Fig. 26). Wear is present on some specimens but most are made of quartzite upon which wear striations are difficult to see under microscopic analysis. A number of cutting tools demonstrate carefully serrated edges with sharp points that produce easily recognized marks on fresh bone, but also become dulled quickly and require regular resharpening for efficient use. At least four broken projectile points suggest use as knives. On two (Fig. 24o, t) a deliberate or use retouch is present on parts of blade edges while on the other two (Fig. 25n, o) the edges formed by the breaks are worn smooth. These were all probably used while still hafted.

Most flakes recovered are the results of tool sharpening although one small area in the bottom level produced a number of manufacturing flakes all of which came from four quartzite cores (See Table 5). Several sharpening flakes were replaced in their flake scars on respective tools as a means of satisfying beyond any reasonable doubt that these were sharpening and not manufacturing flakes (e.g. Fig. 23r, arrow). Resharpening apparently was the result of both hard and soft hammer techniques since on some the lip or overhang adjacent to the bulb of percussion is well preserved while on others there is no lip and considerable shattering is present. Most sharpening flakes fit into identifiable categories which identify the functional nature of the working edges from which they were removed. Those from bilaterally-flaked cutting edges fall into one category. Often enough of the original

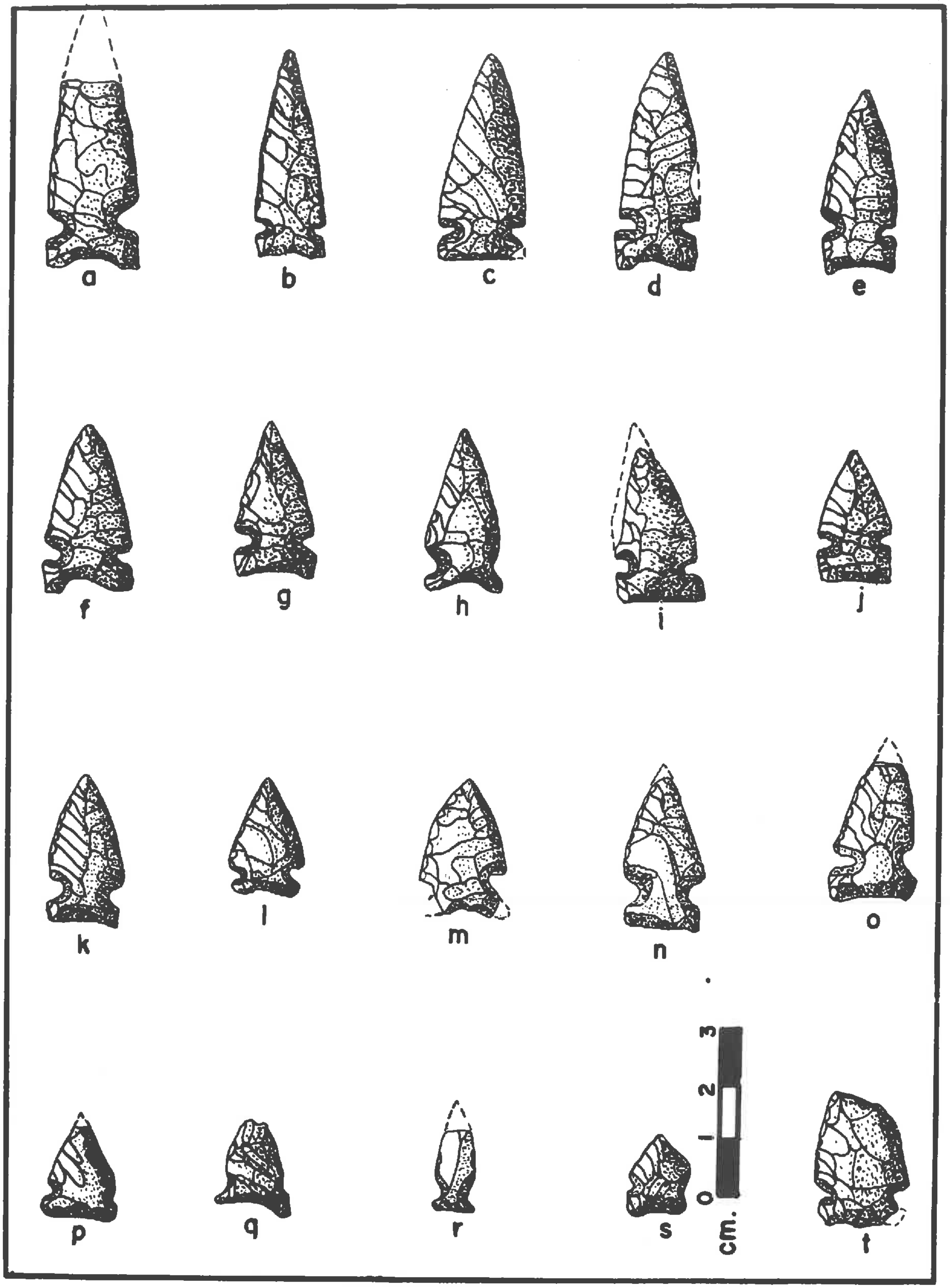

Figure 24 - Projectile points from the bottom level of the Glenrock Buffalo Jump.

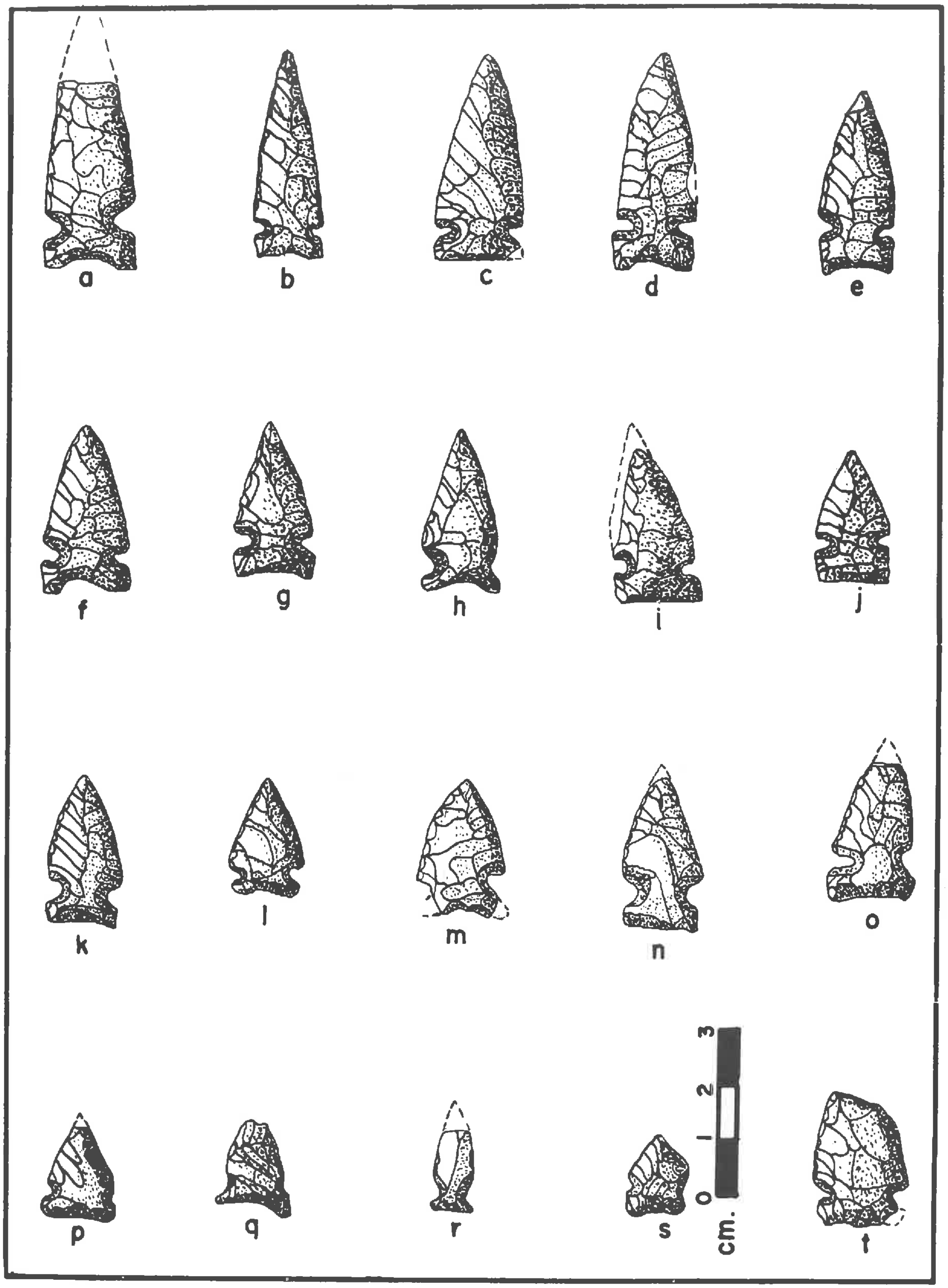

Figure 25 - Projectile points from bottom level (a-n) and top level (o-y) of the Glenrock Buffalo Jump.

TABLE 4. PROJECTILE POINT DATA.			
		Top Level	Bottom Level
Lengths	10 mm. – 14 mm.	6%	–
	15 mm. – 19 mm.	11%	4%
	20 mm. – 24 mm.	33%	14%
	25 mm. – 29 mm.	27%	33%
	30 mm. – 34 mm.	11%	27%
	35 mm. – 39 mm.	6%	18%
	40 mm. – 45 mm.	6%	4%
Widths	17 mm. – 18 mm.	4%	5%
	15 mm. – 16 mm.	31%	34%
	13 mm. – 14 mm.	50%	51%
	11 mm. – 12 mm.	15%	10%
Bases	Concave	57%	91%
	Straight	13%	6%
	Base Notched	30%	–
	Convex	–	3%
Material	Chert*	22%	25%
	Quartzite	75%	72%
	Metamorphosed Shale	3%	2%

*Includes all material ordinarily classified as chert, flint, jasper and chalcedony

TABLE 5. FLAKES FROM THE GLENROCK SITE.					
	Quartz.	Chert*	Metamorphosed Shale	Scoria	Total
Top Level					
Tool Sharpening Flakes	62	23	–	–	85
	73%	27%	–	–	
Other Flakes	–	–	–	–	
Bottom Level					
Tool Sharpening Flakes	1790	169	20	1	1980
	90%	8.55%	1.4%	.05%	
Other Flakes	1657	–	–	–	1657
	100%	–	–	–	

*Includes all material ordinarily classified as chert, flint, jasper and chalcedony.

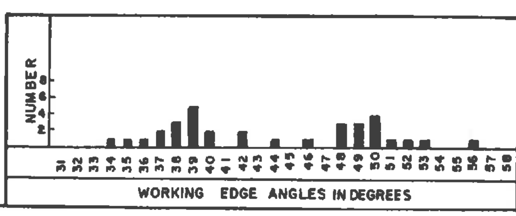

Figure 26. Bimodal clustering of working edge angles of cutting and scraping tools.

working edge is preserved to measure the angle and separate these from sharpening flakes removed from scraping tools. The latter can be identified because of the steeper angles of scraping edges. In addition, one side of a scraping tool is essentially flat, while the other is flaked to form a steep bevel and, as a result, flakes removed from scraping tools are quite different from those removed from cutting tools and can be identified. Flakes removed from side scrapers form three identifiable categories. These have been described by the writer for other site assemblages (Frison 1968; 1970) and need not be repeated here.

In a situation such as this it might be expected to find at least some of the flakes from a single sharpening process concentrated in a small area. This was occasionally true but usually they were widely scattered. For example, the flake that fits the tool (Fig. 23r) was found singly about 30 feet from the tool itself. A small concentration of 14 sharpening flakes is undoubtedly from the same tool and some can be matched together. Consideration of the amount of activity and scattering of bone, however, help explain the scattering of tool sharpening flakes. Pressure flakes consitute a good share of the total number of sharpening flakes but these were recovered by sampling small areas with fine mesh screens and although over a hundred flakes were recovered in this way, this would represent only a small amount of the total.

As in other kill sites (see e.g. Frison 1967; 1970), the sharpening flakes indicate the use of significantly larger numbers of tools than were recovered in the site deposits. From the different stones used, there were at least 150 tools sharpened in the butchering area and this is a very conservative estimate considering that much of the quartzite, which is the most common material used, is similar in appearance and no attempt was made to distinguish between the sharpening flakes other than those that were quite obvious. The number of chipped stone tools do not satisfy the requirements in terms of animals butchered so the flakes, in one sense, actually allow a better interpretation of tool use than do the tools. Flakes recovered in the small stone flaking area of the site are for the most part distinct from sharpening flakes. They are larger than the latter and the angles between striking platforms and the back of the flakes indicate they were driven from biface cores. In additon, striking platforms bear deliberate grinding and lack the evidence of use found microscopically on sharpening flakes.

This completes the tool assemblage which, in the writer's opinion, does provide a rational means of accomplishing the butchering that occurred. There were, in addition, a number of miscellaneous items in the deposits, including several badly-decomposed pieces of cottonwood bark (Populus spp.) and limbs up to 3.5 cm. in diameter. One end of an unidentified branch may have been part of a dog travois. This is suggested by what appeared to be deliberate tapering on one end, although the specimen is rather badly decomposed. It was probably about 3 cm. in diameter originally and the fragment was 35 cm. long with a taper on one end for about 18 to 20 cm. The opposite end was broken. It is reminiscent of what is believed to be a part of a dog travois pole recovered from a dry cave in northern Wyoming (Frison 1965:91). The only other recovered material brought to the site consists of several unworked fragments of local fresh water clam shell (Lampsilus siloquoidea). The end of a buffalo horn sheath 9.3 cm. long, and badly decomposed on the outside, was drilled from the center of the tip outside with a hole .3 cm. in diameter to meet another hole .6 cm. in diameter drilled from the inside at a slightly different angle to allow for the curve of the horn. The inside of the sheath has been shaped. The sheath is believed to be a stem for a tubular pipe.

The Projectile Point Assemblage

A total of 152 identifiable complete and broken projectile points were recovered (Table 4). All are diagnostic of the Late Prehistoric Period. Of some possible significance is that the base notch appears in significant numbers at the top level suggesting some lapse of time between the periods of use of the site. Base notching is believed to be a late occurrence in this part of the Plains.

The projectile points appear as a range of variation of a single type instead of several distinct types (Figs. 24,25). Most are symmetrical with blade edges usually straight or slightly convex and, on one specimen, slightly concave (Fig. 25b). Bases are usually concave but vary to straight and, on two specimens are slightly convex. One side of the base may project more than the other (Fig. 25h, i) and on two specimens the corners of the base project downward (Fig. 25f). Light basal grinding occurs on about half of both straight and concave bases. Most are made on percussion flakes of prismatic cross section with the projectile point tip oriented toward the bulb of percussion. The median ridge of the flake was removed by careful pressure flaking. The flake scar pattern usually is such that the flakes extend toward the center at right angles from one blade edge; on the opposite sides the flake scars extend downward toward the center at less than a right angle with the blade edge. The flat side usually retains part of the original flake face with only light pressure flaking on the edges.

Maximum width is at the base or, less frequently, across the notches. Notches are "v" shaped, rounded, or narrow and quite deep, and in relative size may be small or large. Base notching appears on a number of specimens from the top level (Fig. 25o-t, y), which are otherwise inseparable from the others. At least four suggest use, probably as cutting tools, after they were broken (Figs. 24o, t; 25n,o).

There is a significant number of projectile points that are relatively smaller and of a nondescript nature reflecting an almost complete disregard for care in manufacture. These may represent a different functional category of projectile points (Figs. 24p-s; 25 u-y).

SPECULATIONS AND CONCLUSIONS

Butchering Process

There are few descriptions of butchering without some influence on the process by tools introduced by Europeans. The descriptions that are given lack detail and only incomplete interpretations of the process can be made. A good example and probably the earliest known of New World butchering is that of Castenada. This is a familiar quote and mentions cutting open the carcass at the back using a flint tool tied on a stick which they sharpened with their teeth. Castenada noted something of the process, "with as much ease as if working with a good iron tool . . . The quickness with which they do this is something worth seeing and noting" (Winship 1904:112). Although revealing, it tells us little of the actual process. It is suggestive that it was accomplished with a small cutting tool since there is no mention of heavy choppers or hammers. If so, it mush have represented more of a dissection process in contrast to the methods of crushing and chopping at the Glenrock Buffalo Jump. This account is valuable also in that it predates any European influences. Butchering with stone tools and primitive methods was undoubtedly different than what we are familiar with, but there is no reason to assume it was not a fast and efficient process.

Other accounts are later and reflect the influence of European tools. Lewis Henry Morgan describes butchering of a buffalo hauled aboard a steamboat on his Missouri River trip in 1862. The butchering was done "rapidly and Indian fashion" (Morgan 1959:159) by white men but they were using a steel knife and an axe. The hide was cut down the back after the animal was placed belly down with front and rear legs extended. The hide was described as worthless at this time of the year (June 3), and was used to place the meat upon. No mention was made of the cuts made on the hide other than the main cut down the back. Descriptions of parts and locations of cuts are too vague to be able to abstract other than a general butchering idea from the descriptions.

Nearly two decades before Morgan's trip, Audubon made a trip into the Plains up the Missouri River in 1843 with his companion, Edward Harris (1951:36-7), who kept a journal and gave a long description of buffalo hunting and butchering. His account is as follows:

> "The process of cutting up a dead Buffalo would rather astonish our butchers. The skin is split down the back and the upper side turned over on the ground, a knife is run alongside the spine the whole length and then inserted on top of the ribs is carried at right angles to the first incision taking out the whole of the thick meat on the top of the ribs and along the spine, this piece is called the fleece, or by theCanadian voyageurs, the dupuy. The shoulder is then dispointed and with the foreleg makes another piece, then the thigh, unless they do not wish to take the whole of the meat, in which case they turn the knife down the thigh when cutting out the fleece and lengthen it by taking a piece of the same width and thickness, the meat from the thin part of the ribs and the flank [blank in MS] into another piece. The ribs are then jointed at their connection with the brisket and cut through when they join the spine, this makes the second best piece from the Buffalo, although a novice would be disposed to leave it, there appears to be so little meat upon it. The body being now open the paunch is taken out, emptied and saved, also the coecum with some of the fat and coagulated blood

to make a pudding, tender loins and kidneys are cut out, and if the hunters have been long fasting, they regale themselves with pieces of raw liver and of the manifold washed in the warm blood of the animal, which they profess to consider most dainty morsels, though I never could be induced to taste them. The animal is now turned and the same operation performed on the other side, the hump ribs as they are called are then chopped off at their base and constitute the prime piece, there are ten or twelve remarkable elongations of the spinal processes which form the hump or bosse, the first one, or rather the second one, being sometimes 19 inches in length, they decrease gradually until they reach about the middle of the back, the remainder of the processes to the end of the tail being about the same as in the common ox. The brisquet and the tongue are taken, the brains are frequently taken out and eaten raw by the hunters and sometimes the head is taken home that their squaws may enjoy that dainty morsel. When there are plenty of hands, to cut up, the Buffalo is raised upon his knees and the fore and hind legs spread out, so that both sides may be worked upon at once."

This account is also based on the use of European tools but does illustrate an entirely different concept of butchering than we are familiar with.

Wilson's study of Hidatsa butchering based on informants' descriptions gives some insight on butchering techniques. One of these is that the legs "were skinned almost to the hoof, the ends of the four legs up to the joint were cut off and thrown away" (Wilson 1924:250). This suggests it was easier to skin the animal by cutting the hide around the metatarsals and metacarpals than to make the cut higher on the leg. This is most certainly true from experience in field butchering. It suggests also the amount of meat below the humerus and radius-ulna joint and the femur and tibia joint was not considered of too much importance.Also, according to Wilson's informatant, the head was completely skinned, most of the neck meat was discarded, but the tongue was saved. The different parts were sketched schematically by Wilson's informant, and according to this the pelvis and the lumbars were discarded in one piece but there is no indication of the method of dealing with the pelvis or removing long bones. Carnivores were always common around butchering sites according to Wilson (1924:252). The Flathead built a fire to cook meat to eat as they butchered (Turney-High 1937:119-20). This is a possibility that could explain the several small fires present at Glenrock that did not appear to represent anything but small fires of short duration. Other choice pieces of meat were the tongue and "meat on the breast plate bone" (Wilson 1924:247). The brisket is mentioned as a cut of meat in other accounts including the one by Harris above, by Fletcher and La Flesche for the Omaha (1906:273), and Turney-High for the Flathead (1937:119-20). This suggests the meat on the sternum and costal cartilages was considered to be of value and that the absence of these bones and evidence of their removal from the ribs at the Glenrock site was an established prehistoric butchering practice.

Densmore (1918:443-4) through an informant gave a description of butchering and claimed:

"there was a 'blanket of flesh' on the back and sides of the animal which was removed in one piece, but that before taking this they 'worked up under it' and detached the front quarters."

It is difficult to understand what this so called "blanket of flesh" might refer to unless it is the thin layer of flesh that adheres to the hide during skinning. Actual butchering of buffalo fails to reveal anything that satisfies this description. It was not possible to find any way to "work up under" any blanket of flesh to remove the front quarters unless it referred to the infraspinatus and supraspinatus muscles situated on both sites of the spine of the scapula. It might possibly refer to the longissimus muscle which can be stripped out to include also the flesh on the ribs.

Some interesting observations on butchering were made at the Olsen-Chubbuck site which is considerably older than Glenrock (Wheat 1967). From this, a butchering process reminiscent of that of the later Plains Indians was inferred. In this kill which occurred in late May or early June there must have been an urgency to butcher the animals before spoilage. The analysis resulted in discovery of stylized butchering processes, and evidence as to the disposal of butchering units after they were stripped of meat. Many provocative interpretations and questions and an exhaustive study of the literature on primitive New World butchering is to be found in the final report which will hopefully be published soon. From it good comparisons between Paleo-Indian and Late Prehistoric butchering methods and techniques may be possible.

There are many other accounts of butchering but further enumeration of these would add little to the interpretation of the Glenrock site. The buffalo jump or trap was a special situation in which the number of animals killed determined the degree of carcass utilization, which in turn affected the methods of butchering. These factors could change from one drive to the next, although there is no indication that overkills were a common occurrence at this site. Maximization of effort was necessary in a situation of this nature to prevent spoilage. The marks preserved on bones indicate some of the technological processes used and the tools recovered indicate others. Together they provide the framework for a reconstruction of the butchering process. Further work in similar sites should add much to the present knowledge of butchering especially where processing and camp areas can be located.

Bison Handling

Buffalo jumps are a common archaeological feature in the Northwestern Plains. They were an important factor in cultural continuity and their time depth is still very much in question. In Wyoming and southern Montana, both jumping and trapping have been solidly established as soon as altithermal conditions ameliorated (Bentzen 1962; Frison 1968, 1970). There is no reason why these techniques should not have greater time depth in other areas where altithermal conditions were not so pronounced and bison populations not seriously affected. It seems likely that these or similar methods of communal bison procurement were already in use in other areas before the buffalo returned to this part of the Northwestern

Plains in significant numbers in the post altithermal period.

The hypothesis proposed by the writer is that communal bison procurement was part of a yearly pattern on the Northwestern Plains with the result that populations came together in the fall for a short period and fragmented the remainder of the year. This pattern persisted until historic times and the introduction of the horse. The horse brought changes in buffalo procurement methods that were as profound as the changes in butchering resulting from the introduction of steel knives and axes.

There is a body of knowledge concerning Bison bison that can be obtained by first hand observance of the animals. It must be remembered, however, that even though there are a number of large public and private herds extant, there is a limit to what can be generalized from these herds into a pre-horse situation.

Among other things, present day buffalo are used to fences, artificial feeding, periodic trips through corrals and chutes where they are innoculated, tagged and tested for diseases. If hungry they usually come to a man and vehicle, expecting a handout which is far from their normal behavior in the wild. In spite of this, there are some observations that can be made that are relevant to prehistoric buffalo handling. For instance, a buffalo cow or small calf can be disruptive to moving a herd especially where close control over long distances is necessary for success. The same cow comes into rut about three months after calving. During the rutting season, driving without horses is especially difficult. Cows with bulls in pursuit go in any direction at any time, again making a carefully controlled drive diifcult. At the end of the rut, the mature bulls (five years and older) lose interest in the cows and move off to themselves singly or in groups of various sizes. Normal daily movements of the animals may bring them together from time to time but they soon drift apart again. Mature bulls are diffiuclt to drive at any time and if they are with a herd will try to slip away as soon as possible. It is a distinct advantage to get older bulls out of a herd if a controlled drive over a long distance is to be accomplished even with the use of horses.

These aspects of buffalo behavior can undoubtedly be applied to pre-horse conditions. The buffalo drive at Glenrock required controlled movements of herds over distances of one to three miles. There are always a delicate balance between success and failure in the process. It takes little to start a wild herd into an uncontrollable stampede. During the fall the element of control over the herds could be exercised with a greater probability of success than at other times of the year but even then there were many elements of uncertainty present and the possibility of losing a herd was high.

Religious Activity

Religious activity appears in many contexts of communal procurement practices. This is documented for the Cree by Mandelbaum (1940:190-1), for the Crow by Medicine Crow (1962:35-8), for the Assiniboine by DeSmet (Chittenden and Richardson 1905:1028-9) to mention only a few Plains tribes in buffalo procurement contexts. Shamanistic activity in antelope procurement is described by Steward (1938:34) for the Shoshone and by Hoebel (1960:65-6) for the Cheyenne. Communal procurement for caribou among the inland North Alaskan Eskimo is described by Spencer (1959:354). There are numerous other accounts but this should be sufficient to establish the importance of supernatural activity in these kinds of situations. Sahlins (1968:98) points out that in conditions of economic uncertainty supernaturalism can be expected. Aberle (1966) discusses magic and its relationship to situations which are unpredictable and uncontrollable. The ethnological and historical evidence of religious activity has been well established and archaeological evidence is beginning to indicate the same. A large religious structure at a late Plains Archaic buffalo pound seems of relevance (Frison 1971). It is quite possible that the amount of evidence for supernatural activity found can be used to argue for the idea of unpredictability and uncontrollability of buffalo driving, jumping and trapping.

Projectile Points in Buffalo Jumps

The total number of projectile points recovered from Glenrock is quite small considering other sites for the same time period (see e.g. Frison 1967, 1970). There are several considerations concerning the projectile points found in buffalo jumps. Many of the postulations on the subject are quite speculative, reflecting the lack of positive evidence. In the absence of good solid data, some of these speculations should be considered. An early attempt to synthesize data on buffalo jumps was done in 1962 (Malouf and Conner 1962) based on the evidence from ethnology, historical accounts, tribal traditions and limited archaeological evcavations. In a panel discussion, it was mentioned (Malouf and Conner 1962:42) that some amateur archaeologists in Montana attribute small projectile points in jump sites to shooting into the herd to excite them into stampeding. Lacking good evidence, this idea has merit but there are some aspects of bison handling to be considered. Shooting arrows into a herd would undoubtedly excite the animals but the immediate reaction of the animal would be almost totally unpredictable and might start a stampede but in the wrong direction. Once the animals were stampeding in the proper direction, then a few well placed arrows might aid the process, but to keep the stampede headed in a proper direction it was necessary to have men stationed at proper intervals to close in on the rear of the herd and keep it moving. The danger to these people is immediately evident if it was common practice to shoot into the herd. The best way to control a herd of buffalo or range cattle is to gauge you and your companions' movements carefully in relation to the position of the herd. In summary, shooting arrows into a buffalo herd at the wrong moment could ruin the entire effort, while shooting arrows into the rear of a stampeding herd would be relatively ineffectual compared to other more effective action that could be taken. In addition, this process would have been dangerous to the persons involved. This does not seem a logical source of the projectile points in the kill areas of buffalo jumps.

The same volume speculates that the small projectile points were the result of killing carrion-eating birds that collected at the site (Malouf and Conner 1962:27). This merits further consideration in that a situation of this nature attracts not only birds but animals as well. It is certainly within reason to think that members of the group concerned, especially young boys, would shoot or attempt to shoot predators that certainly appeared. Bear, coyote, and bobcat bones were found in one jump (Frison 1967), suggesting that this site served to attract these animals. At the Kobold site, a number of projectile points did not fit the normal range of variation and these may have been the result of some acitivity other than killing buffalo (Frison 1970:20). A similar group of projectile points form a significant part of the Glenrock assemblage and the idea of hunting at the site seems reasonable. The bones of such birds or animals need not be found regularly to support this contention since no small boy ever kills anything under these condition without proudly carrying it with him to display it to anyone who can be coerced into giving notice.

The most logical explanation for projectile points in kill areas of buffalo jumps, in the writer's opinion, is the killing of crippled animals. The Glenrock Buffalo Jump contained relatively few projectile points. This was fortunate in that it probably saved the site from destruction since most collectors could find nothing they considered of value and subsequently interpreted the site as nothing more than a winter-kill of cattle. The reason for so few projectile points is believed to be a function of the lethal nature of the jump. However, even with a jump-off such as Glenrock, when a number of animals piled up at the bottom, many of the later animals to come over would have been crippled and some would have gone unharmed considering the absence of a restraining structure at the bottom. Unless the cripples were totally unable to move, the best method of dispatch would have been to shoot them with arrows and let them rest and stiffen for a period of time. A wild animal can be mortally wounded and if approached, gain its feet and move a considerable distance before stopping. Even a freshly wounded animal with a broken back or two or even three broken legs can force itself to move a considerable distance if approached too closely by a human. It is quite obvious that the hunters wanted the animals in one location, as close as possible to the processing area, in this kind of procurement activity.

In conclusion, there are at present many voids in the knowledge of the prehistoric Plains buffalo economy. The writer has postulated communal fall buffalo procurement as the mechanism that annually brought the consolidation of small units of Plains societies into temporary larger ones. This may work on paper but we are largely ignorant of the ups and downs of the Plains bison populations through time. According to historic accounts bison populations were quite high but it was only with introduction of the horse that the Plains became a culture center based on exploitation of the bison herds. Before this, the culture center of the Plains developed as a result of agriculture in favorable areas.

This suggests that if the bison populations were at all stable throughout the Post-Altithermal, methods of bison procurement were never too effective and never offered any serious threat to their existence. Earlier jumps and traps (see e.g. Frison 1970, 1968) seem every bit as sophisticated as those at the end of the Late Prehistoric period. It does not appear that, in Post-Altithermal times at least, there were any significant changes or improvements in procurement techniques and at best, they were relatively ineffectual in terms of exploitation of the total bison resources. When the horse was introduced into the system , the buffalo was in the opposite position and could then be lethally exploited to provide the necessary resource base for a year around food supply. This allowed population increases and the emergence of a short-lived culture center. This was when buffalo jumping lost its popularity since it was no longer a necessary economic activity.

The Genrock Buffalo Jump was probably used for a long period of Late Prehistoric time ending with the historic period and the introduction of the horse. At least one more jump and probably others were associated in the same complex along a scarp several miles in length. The scarp provided several favorable locations where the animals could be stampeded over perpendicular bluffs.

The buffalo herds had to be consolidated and moved over distances of more than a mile and then stampeded under carefully controlled conditions to get the animals crowded over the jump-off. The limits of the drive lane and the final stampede are marked by small stone piles. Several small stone circles that do not represent house structures are interpreted as evidence of religious and shamanistic activity common to communal buffalo and other economic procurement activities.

Good preservation of a large proportion of the bone material allowed a reconstruction of the butchering process based on recovered tools and marks on the bones. Butchering was a stylized process, relying strongly on simple tools many of which were obtained at the site from the animals themselves and adjacent sources of stone materials. A processing area was probably close by but was never located. Further efforts to locate a processing area are important and needed to test the hypothesis on butchering presented above.

ACKNOWLEGEMENTS

Inveситgation of the Glenrock Buffalo Jump was made possible through a grant from the National Science Foundation. In addition, many others volunteered services that aided the project and made the undertaking more pleasant. Mr. and Mrs. Dale Valentine, owners of the property on which the site is located, donated the use of a house and utilities during the field season and cooperated to the fullest extent in many other ways. Several members of the Casper Chapter of the Wyoming Archaeological Society contributed to the project and are to be thanked. These include Bart Rea for his excellent services in mapping the site area; Henry Jensen for walking out and marking the buffalo drive lines; Florence Coates, John Barber and Mary Garling for their help in the field and many gestures of kindness to the crew.

The regular crew consisted of Charles Reher as foreman and Ross Hillman, Roger Garling, Paul Pownall and Steve Wagner. Several others including Terry Bean, Timothy Karnes, Anita Klaenhammer and Rick Albanese worked part time.

In addition, the writer is deeply indebted to the Wyoming Recreation Commission for summer support to pursue Wyoming archaeology.

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APPENDIX I

AGE DETERMINATION OF BUFFALO BY TEETH ERUPTION AND WEAR

By George C. Frison and Charles A. Reher

In order to test the hypothesis that buffalo jumping was limited to a certain time of the year the age of the animals at time of death had to be determined. This was done by means of lower tooth eruption and wear from a sample of 251 complete or fragmentary mandibles from which aging data could be obtained. The method of tooth sectioning to determine layers of cementum was not attempted.

If the jumping period was limited to the fall of the year the animals should reflect yearly age grouping, assuming that the schedule of tooth eruption and time of birth was narly the same for all animals. Assuming a peak of calving toward the last of April and the first of May and a jumping season from late September to early November, the age grouping of the buffalo should cluster at about .5 years, 1.5 years, 2.5 years, 3.5 years, etc. The sample would have to be large to allow for the occasional late calves that normally appear.

The younger animals are the most reliable for purposes of aging, since tooth eruption can be used. In the older age groups, reliance must be made on tooth wear which should be valid in a single area but which can change rapidly over geolographical areas. Domestic animals demonstrate different degrees of tooth wear depending upon existing range conditions. The incisor teeth are the most sensitive guide to aging, but due to butchering practices and loss of the anterior parts of the mandible through bone decomposition, they were usually not available.

Attempts to use mandibles from the various breeds of domestic cattle were not successful. Bison in general are a longer-lived animal than Bos and there are also some differences in tooth eruption schedules, especially with the incisors. It was apparent from this that specimens of known age were necessary and these were obtained from several different buffalo herds in Wyoming. By far the most informative group of specimens was obtained through the courtesy of Arthur Busskohl, manager of the Durham Meat Company near Gillette, Wyoming, who maintains a large commercial buffalo herd and butchers large numbers of animals of known age. Entire skulls were skinned and saved intact so that large numbers were available, mostly in the 2-1/2 to 3-1/2 year age groups with lesser numbers available in the 1/2, 1-1/2, and old age groups. Another sample of reasonably well known age was made available by the Zoology Department of the University of Wyoming, which had nearly a hundred mandibles from the Yellowstone National Park herd. A small but valuable sample, including a three day old calf and a 4.6 year old bull were obtained from George Crouse, a buffalo raiser near Laramie, Wyoming.

By using known-age samples, the mandibles from the Glenrock Jump fell in general age categories as follows:

Group I, .5 year - all decisuous incisors and premolars in place, DP2 and 3 moderately to well worn, DP4 moderately worn; M1 erupted but usually not to level of other teeth, M1 is unworn or slightly worn on highest cusp; partially formed M2 can sometimes be seen in the opening behind M1; tooth row about 9-10 cm. long, mandible 26-28 cm. long (Fig. 1a,b).

Group II, 1.5 years - I1 erupting or just about to erupt; DP2, 3 and 4 well worn and have roots showing as they are being pushed out; M1 moderately worn; M2 usually unworn and not fully erupted or shows only slight wear; M3 still being formed in jaw and can be seen through opening behind M2; tooth row 11-12 cm. long, mandible about 33 cm. long (Fig. 1c, d).

Group III, 2.5 years - I1 erupted and worn; DI2, 3 and 4 extremely worn; I2 about to erupt; DP2 and 3 extremely worn, sometimes sitting on partially erupted permanent tooth and just barely rooted in jaw; P2 and P3 accordingly are usually partially erupted or close to eruption; DP4 extremely worn, but not pushed out as far as other deciduous premolars; M1 and M2 moderately to well worn; 1st and 2nd cusps of M3 erupted but never 3rd cusp. tooth row 14 to 15 cm. long, mandible from 34-37 cm. long (Fig. 1e).

Group IV, 3.5 years - I1 and I2 in place and worn; DI3 in place or gone, I3 erupting or about to; DI4 extremely worn; P2 and P3 moderately worn; P4 partially erupted and unworn or fully erupted but only slightly worn; M1 and M2 in regular use; 3rd cusp of M3 erupted but always unworn; tooth row 16-17 cm. long, mandible around 37-38 cm. long (Fig. 2a).

Group V, 4.5 years - I1, 2 and 3 in place and worn; DI4 in place, or gone with I4 erupting (Fig. 2d); P2, 3 and 4 moderately to well worn; M1 and M2 in regular use; 3rd cusp of M3 slightly worn, usually just through enamel exposing dentine in small area; posterior style between 2nd and 3rd cusps still always unworn; tooth row length and madible length reach final size of around 15 to 16 cm. and 40 cm., respectively (Fig. 2b,c).

Group VI, Mature, 5.5 to 9.5 years - all permanent teeth fully erupted and in regular wear, including 3rd cusp of M3; there is a relatively large variation in the wear because the group contains several years of age; enamel still always continuous around the teeth and fossi are still in evidence (Fig. 2e, f).

Group VII, Old age 10.5 to 13.5 years - all teeth extremely worn, especially P4 and M1 where wear "dips" well below level of other teeth; anterior fossa of M1 always obliterated as tooth is worn into continuous dentine of root, posterior fossa usually gone too; enamel often only left around one small area of posterior side of M1; there are fair amounts of variation within this group because it too contains several years of age, but wear is never less than as was characterized above; in very extreme cases some teeth are completely gone, or only separate roots are left standing in the mandible (Fig. 3a, b). A mandible from a 13 year old cow (Fig. 3c, c') illustrates quite well the old age category.

Based on tooth eruption, the first five groups from the Glenrock Jump are quite distinct with essentially no intermediate specimens. This argues strongly for a seasonal pattern of procurement. A further breakdown, made of the mature (Group VI) and old age (Group VII) categories, based on tooth wear is discussed in the population study. For reference, the mandibles of a 3 day old calf are included demonstrating all deciduous incisors and premolars erupted (Fig. 3d, e).

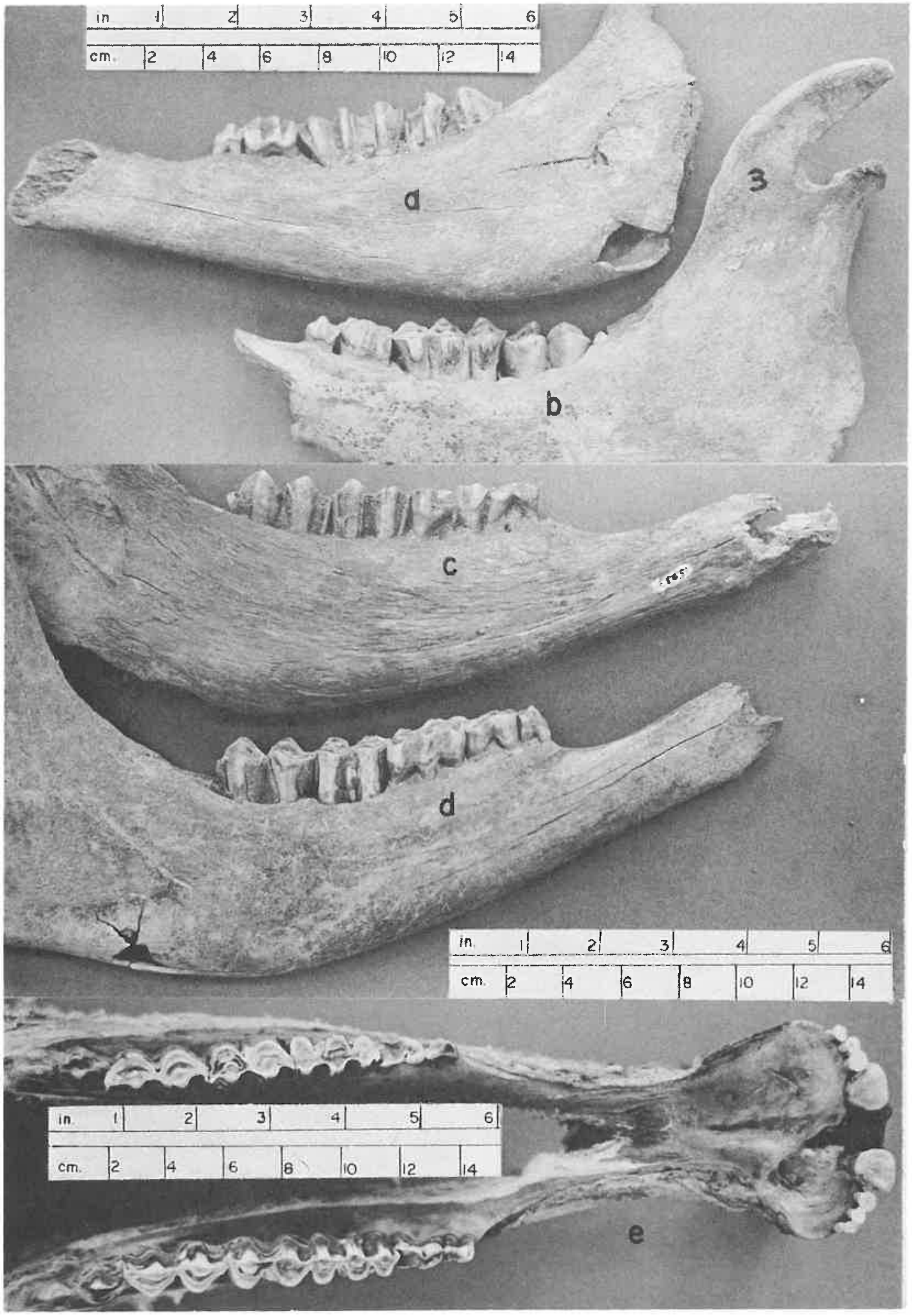

Figure 1 - Mandibles of a .5 year old (a-b), 1.5 year old (c-d), Bison bison from Glenrock Jump and a 2.5 year old specimen from a local herd (e).

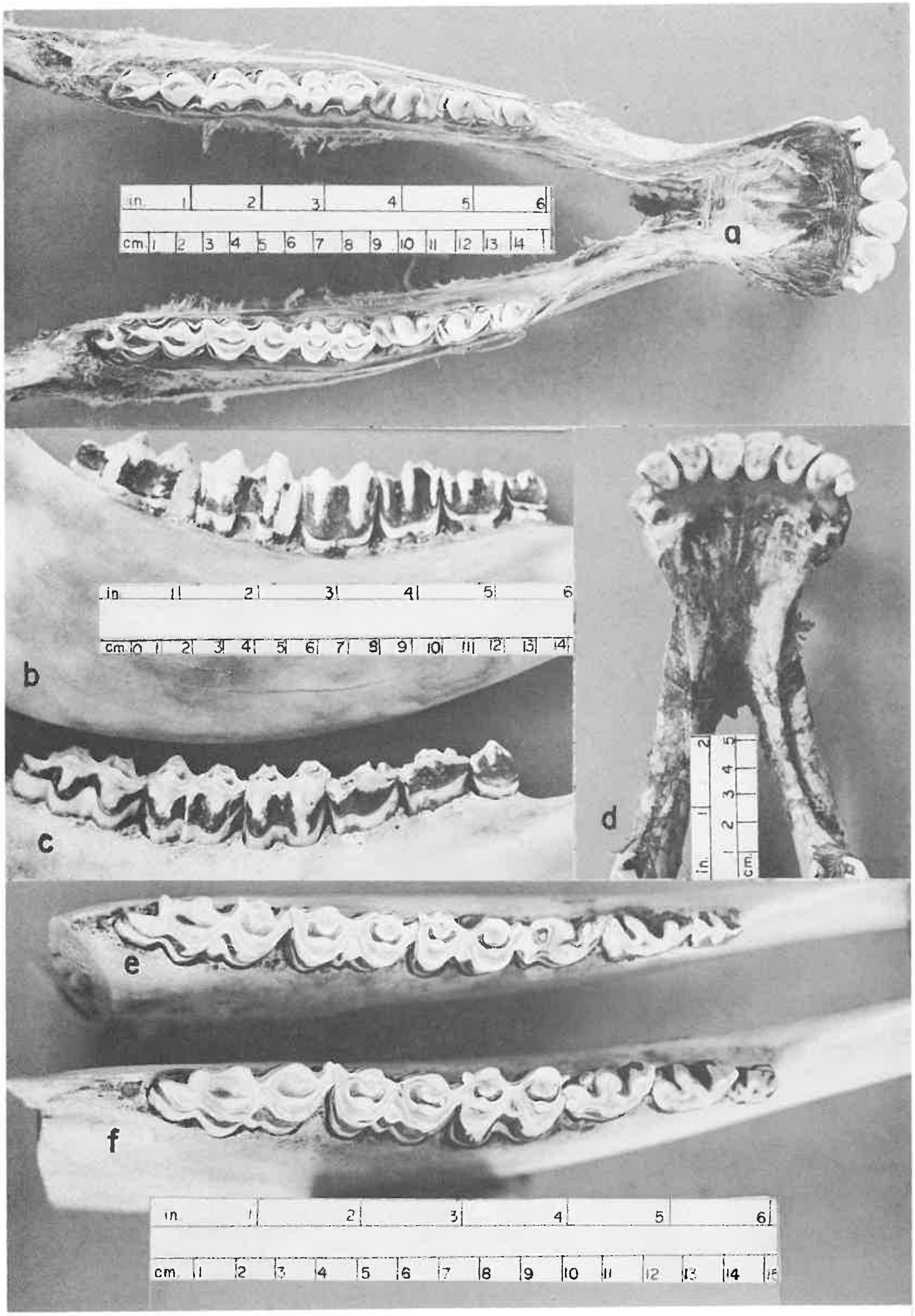

Figure 2 - Bison bison mandibles from a 3.5 year old (a), 4.5 year old (b-c), incisors from 4.6 year old (d) and mandibles (e-f), all from local herds.

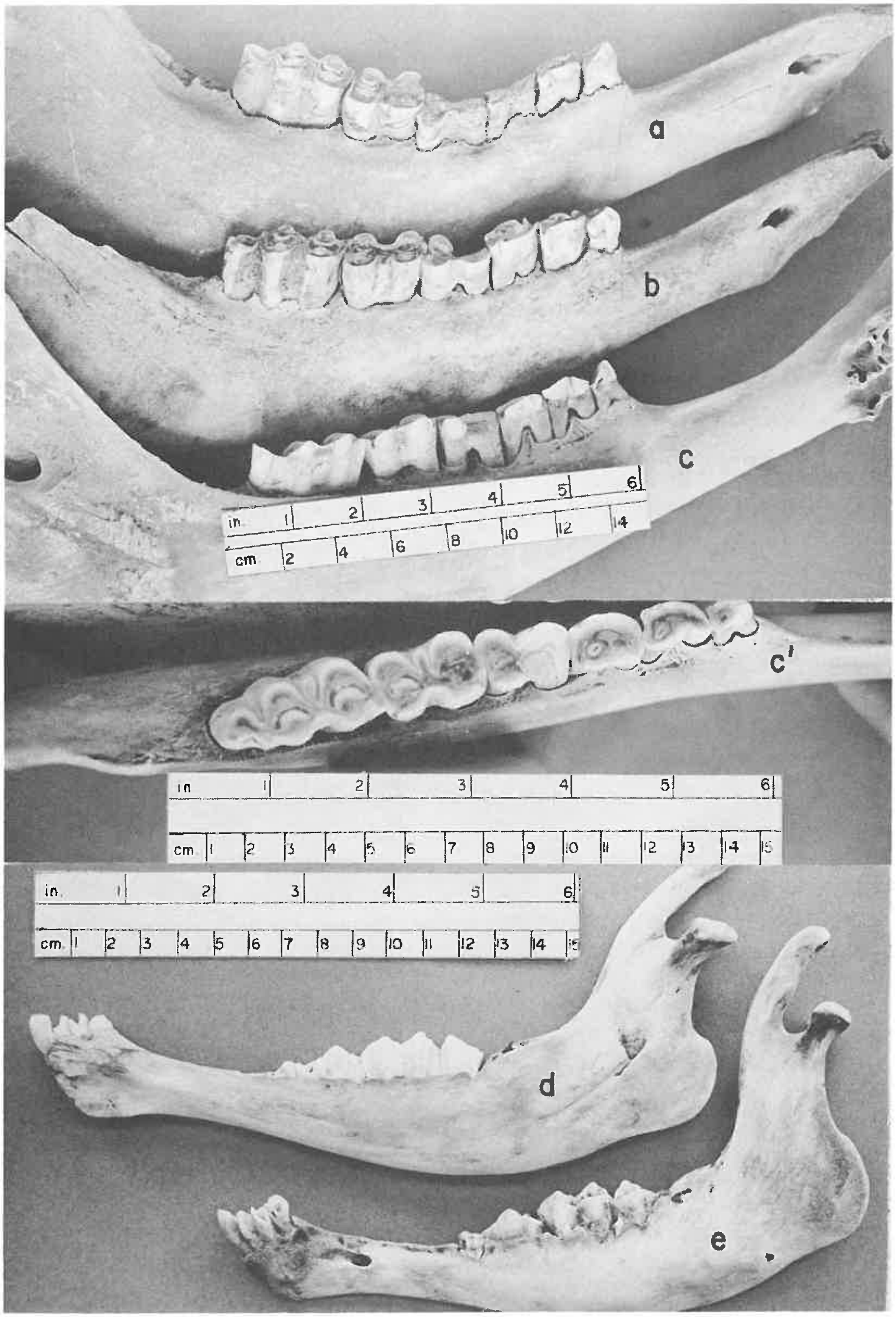

Figure 3 - Old age Bison Mandibles from Glenrock Jump (a-b), and a 14 year old cow (c-c[1]) and a 3 day old calf (d-e) from local herds.

APPENDIX II

POPULATION DYNAMICS OF THE GLENROCK *Bison bison* POPULATION

By Charles A. Reher

INTRODUCTION

Population dynamcis refers to the balance between births and deaths and to the age distribution within a natural population. These parameters are condensed into life tables, survivorship curves and othermedia to better demonstrate the workings of life processes within a species. Mandibles or maxillaries are commonly used since they provide most readily the data needed. The bone preservation at the Glenrock site, which allowed the recovery of 251 mandibles, offered a unique opportunity for this type of analysis. Reliable population dynamics are available for only a small fraction of modern and fossil species. This is especially true for a large and relatively scarce animal such as the American Bison bison.

This study has important relationships to prehistoric communal Bison bison procurement practices on the Plains. Although a buffalo jump reflects a catastrophic mortality, it is unique in that the composition of the population has been altered by cultural activities.

Age Structure

The critical point in population dynamics is the determination of individual age. As was demonstrated in Appendix I, the Glenrock bison mandibles were separable into age groups on the basis of observable tooth wear and tooth eruption. This argued for a seasonal pattern of use of the site.

Groups VI and VII, as described in Appendix I include more than one year of age each. Certain of these mandibles could be assigned to definite years of age by measurements of tooth wear but about 50% of the "mature" and "old age" mandibles were unmeasurable due to tooth damage during the butchering process. For this reason they were included in the two more generalized groups.

When morphological features fail to distinguish age groups they can sometimes be separated by multimodal trends in tooth wear. Four of the seven age groups in a fossil antelope population were distinguished in this manner by Voorhies (1969:28-30). Although Bison bison teeth from the Glenrock site seem to demonstrate more variation than Voorhies found for <u>Merycodus</u>, one year-age groups were indicated within Groups VI and VII (Fig. 1a-b). This variation can be seen in the small amount of overlap between each category. A relatively good sample was available for Group V (4.5 years of age) and is included in Fig. 1b to further show characteristics of tooth wear. These distributions do not reflect the relative strength of each age group, but only the number of measurable specimens.

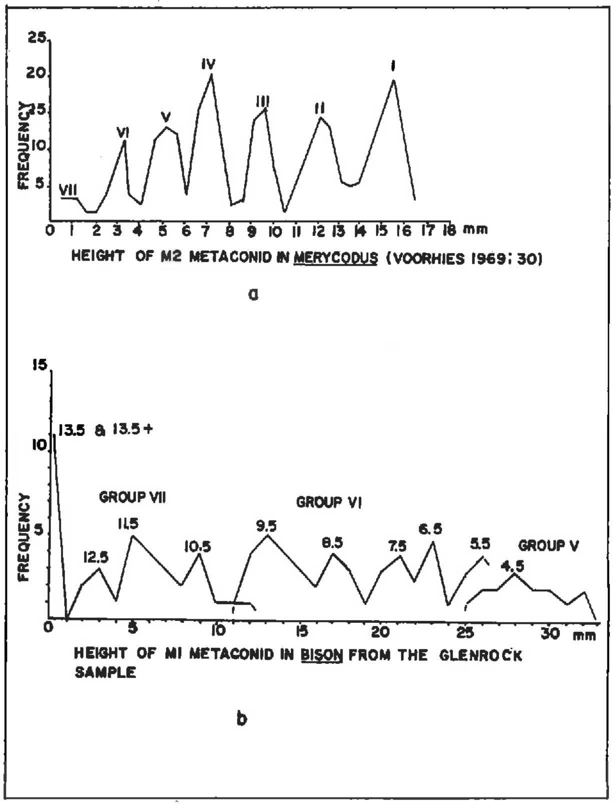

Figure 1 - Melaconid Height in Merycodus (a), and Glenrock Bison Sample (b).

Age Group	Enamel Height	Number of Measurable
I (.5 yrs.)	54.1 mm.	2
II (1.5 yrs.)	46.3	3
III (2.5 yrs.)	38.2	3
IV (3.5 yrs.)	34.7	12
V (4.5 yrs.)	28.8	14
VI (5.5 yrs.)	25.4	8
(6.5 yrs.)	22.5	7
(7.5 yrs.)	20.4	8
(8.5 yrs.)	17.0	9
(9.5 yrs.)	13.2	17
VII (10.5 yrs.)	9.3	9
(11.5 yrs.)	5.6	13
(12.5 yrs.)	2.5	5
(13.5 yrs.)	0.0	11
(13.5+ yrs.	0.0	

Table 1 - Mean Enamel Heights of the M1 Metaconid for all Age Groups.

Enamel heights on M2 and M3 metaconids have been utilized in previous studies. However, these measurements could only be obtained with extensive damage to the mandibles so the M1 metaconid was used instead.

If valid, the results tabulated in Fig. 1b indicate that Group VI includes animals of approximately 5.5, 6.5, 7.5, 8.5 and perhaps 9.5 years of age. The pattern for Group VII would then indicate ages of 10.5, 11.5, 12.5 and 13.5 years. The last category, with enamel height equal to 0, contained a few individuals with such advanced tooth wear that they might be older than 13.5 years.

Wear measurements were not needed to distinguish younger groups, nor were they warranted by the small sample size. However, a few were opened and a few were already broken so that the base of the M1 enamel was exposed. These measurements demonstrate that the multimodal trends continue through all age groups. The averages of these measurements are included (Table 1).

Bimodality of Mandible Size

Population dynamics are based on an entire breeding population. It was therefore necessary to determine whether a segment of the Bison population was underrepresented at the Glenrock Jump. Also, if estimates of the number missing could be derived, it would be possible to still approximate certain population dynamics. In some of these, such as survivorship curves, the general mortality configuration is more important than the exact figures.

Bimodality of measurements of certain skeletal elements such as metapodia have been used to define sex ratios within a population. To maintain a more direct correlation between sexing data and all population data it was decided to attempt sexing by the mandibles alone.

Although a few mandibles appeared to be more rugged and larger, direct observation was unsuitable for accurate sexing results. A number of measurements were tried, including lengths and widths between various points on the jaw and indexes combining these dimensions.

Butchering techniques rendered many mandibles unsuitable for measurement of length and, in general, Bison mandibles seem to demonstrate less difference in length than might be expected. Indexes combining measurements proved to be more complicated than necessary and were also found not to be especially reliable indicators of differences in mandible size.

The more massive musculature of the mature Bison bull seems to result in the greatest increases in size below the cheek teeth. Also, the butchering process more often left the mandible more complete below the molars and premolars than it did the length. For these reasons the widths below M3 and P4 were used to sex the Glenrock mandibles.

Results suggest that in the Glenrock kill only 9% to 14% of the animals were mature bulls (Fig. 2a-b). It is known that after the rutting season the mature bulls tend to congregate by themselves which could be a contributing factor if the kill occurred in the fall of the year.

A slight bias in favor of females is not unusual in ungulate populations. It is therefore estimated that 26% to 31% (at a 60:40 sex ratio) or 31% to 36% (at 55:45) of the mature breeding animals in the whole population are not represented in the Glenrock death assemblage.

Measurements of younger animals should also have a bimodal pattern, but in more equal proportions since the younger males would be present. However, this requires a larger sample than was available for these groups. A vague bimodal trend was indicated for Group V (Fig. 2c, d) but it is far from conclusive.

Attritional and Catastrophic Mortality

Attritional mortality, the normal "dying off" of members of a population, will be reflected in a death assemblage by a preponderance of very young and very old individuals (Deevey 1949:289). Catastrophic mortality, the result of some calamitous occurrence, will freeze the population as a whole and will contain more viable adult specimens. A generalized age-group distribution for attritional mortality is given in Fig. 3a. An attritional distribution is shown from a table of age groups (Skinner and Kaisen 1947:138) on fossil Bison (Fig. 3b). In contrast, a generalized configuration for catastrophic mortality is shown (Fig. 3c).

The Glenrock sample was found not to have the age-group distribution for catastrophic mortality of a total population. From the distribution that was derived (shown by the solid lines in Fig. 3d) it is apparent that a large number of immature animals and some mature animals are not represented in the Glenrock death assemblage. In the previous section it was demonstrated that most of the larger bulls would not have been among the animals killed at the site. Poor preservation of the smaller, more delicate elements has accounted for a similar lack of immature animals in other populations (Kurten 1953:67). However, from personal observation this must be discounted at the Glenrock site since preservation was excellent for all elements. A better explanation would be removal of smaller animals to another location for butchering.

Comparison of the Glenrock age-group distribution to a normal distribution for catastrophic mortality should give estimates of the number of animals missing. Adding the missing large bulls and then computing the expected number of immature animals gives the configuration of the total population. These additions are represented by the dashed lines in Fig. 3d. By including the immature animals presumably removed from the site, but not the large bulls, the 251 mandibles recovered should represent a total of about 195 animals. Since these mandibles were recovered from excavation of only about 20% of the site area, at least 1000 animals were killed at the site, disregarding the loss

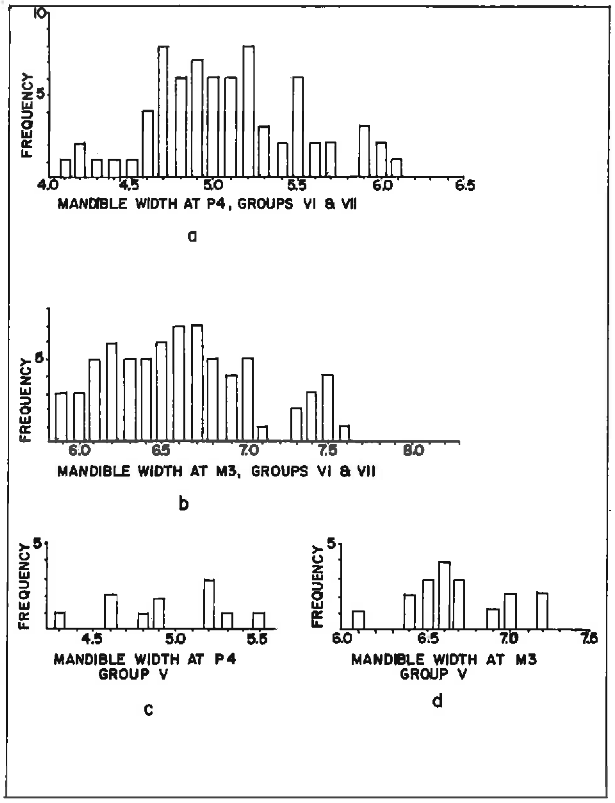

Figure 2 - Bimodality of Mandible measurements for the Glenrock Bison sample.

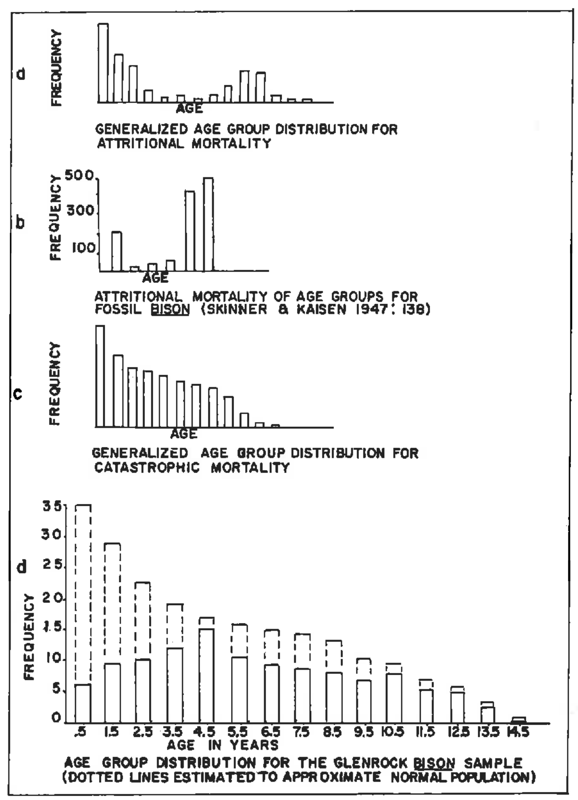

Figure 3 - Age group distributions for attritional mortality (a-b), and catastropic mortality (c-d).

of specimens through processes of erosion which could easily double the estimated number.

Life Tables and Survivorship Curves

The vital statistics of mortality and life expectancy for each group within a population can be tabulated in life tables. For an excellent discussion and explanation of this aspect of population dynamics see Voorhies (1969:24-6).

The Glenrock data are fitted to the "time specific" or "vertical" life table. This type is constructed from information obtained by (1) observation of age structure in a living population; or from (2) the age at death of the members of a population known to have been killed catastrophically in a single occurrence or in successive seasonal deaths.

Calculations are simplified by setting up on the basis of an initial cohort of 100, 1,000, or 10,000 animals. Age is represented by the symbol x and is expressed in time units suited to the life span of the species. The symbol dx represents the number of deaths during an interval and lx denotes the number of survivors at the beginning of an interval; qx is the mortality rate, usually given as per 1,000 or 1,000 qx; ex is the life expectation for an animal of a certain age. The life table derived for the Glenrock Bison is presented in Table 2.

The lx value can be calculated by using ratios after giving the initial group (Group I) a value of 1,000. If, for example, Group I has an estimated 70 animals and is equal to 1,000, Group II with an estimated 55 animals is equal to 786 and so on. The 786 survivors at the beginning of Group II gives a dx of 214. The mortality rate per 1,000 (qx) is $1{,}000 \div \frac{dx}{lx}$ or $1{,}000 \div \frac{214}{1000}$ or also 214. Calculating life expectancy is somewhat more complicated and is done by dividing the number of "person years" remaining to the survivors by the number of survivors: the formula $\frac{lx + lx + 1}{2} = Lx$ is followed for each age group and the one below it (lx of Group I + lx of Group II + 1 ÷ 2 = 1,000 + 786 + 1 ÷ 2 etc.). The values for lx are then summed up to the age group dealt with and divided by lx to give ex. For example, in Group I the sum of all the lx values is equal to 5871, and dividing 1000 equals an ex of 5.87.

If lx is plotted against x, the line connecting these points represents a survivorship curve. Semilog paper is used, x on the arithemetic scale and lx on the log scale, so that the absolute numbers of individuals in each age group does not affect the shape of the curve. The survivorship curve based on the above life table is given (Fig. 4).

Conclusion

In such a context as the buffalo kill, population dynamics can be a valuable aid to archaeological interpretations. With these techniques, parameters, such as seasonality and the absence of certain age groups, can be demonstrated. Under certain conditions population dynamics can be a more reliable indicator of animals utilized than different types of "bone counts."

TABLE 2 - Approximate Life Table for Bison bison from the Glenrock Site.

x = age of the animal in years
lx = number of survivors at the beginning of an interval
dx = number of deaths during an interval
qx = mortality rate = $\frac{dx}{lx}$
ex life expectancy of an animal of a given age in years

Group	x	lx	dx	1000 qx	ex
I	.5	1000	214	214	5.87
II	1.5	786	143	182	6.33
III	2.5	643	100	156	6.47
IV	3.5	543	72	133	6.75
V	4.5	471	28	59	6.70
VI	5.5	443	14	32	6.09
	6.5	429	15	35	5.27
	7.5	414	28	68	4.45
	8.5	386	29	75	3.73
	9.5	357	28	78	2.99
VII	10.5	329	86	261	2.20
	11.5	243	57	235	1.80
	12.5	186	86	462	1.20
	13.5	100	71	710	.80
	13.5+	29	29	1000	.51

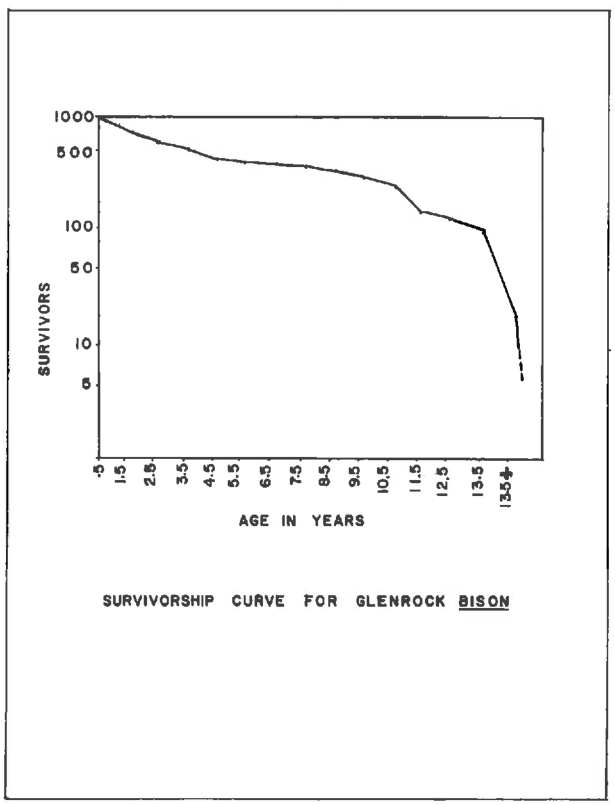

Figure 4 - Survivorship Curve for Glenrock Bison bison.

A separate campsite or meat processing area was not found associated with the Glenrock site. The fact that about 85% of the .5 year old calves and 40% to 65% of the 1.5, 2.5, and 3.5 year old animals were removed suggests that this area was not far away, although it may have been lost through processes of erosion. Archaeological excavations at a kill site may be the only remaining source where material for population studies with Bison bison can be obtained in sufficient quantities. It is demonstrated also that population studies in sites of this nature must take cultural activity and behavioral characteristics of the animals into consideration before proper interpretation is possible.

ACKNOWLEDGEMENTS

The writer is indebted to Dr. Paul O. McGrew, paleontologist at the Department of Geology, University of Wyoming, for his help and guidance in analyzing the Glenrock material and, also, for providing space and equipment for the study.

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APPENDIX III

GEOLOGY OF THE GLENROCK SITE AREA, WYOMING

By John Albanese

ABSTRACT

Quaternary sediments in the Glenrock site area are of post altithermal age. Three alternating cycles of deposition and erosion are evident. The cultural material at the site is contained in a sedimentary unit composed of slope wash material that has yielded radiocarbon dates of A.D. 1690 ± 100 and A.D. 1760 ± 100. Geologic data would indicate that deposition occurred prior to these dates and that the site has a minimum age of between 450 and 750 years. The unit containing the cultural material is older than the Lightning formation, the youngest depositional unit in the area. Erosion and downcutting began between A.D. 1880 and A.D. 1900 and has continued to the present.

LOCATION AND GEOLOGIC SETTING

The Glenrock site (48CO304) is located in the center of Section 11, Township 33 North, Range 76 West, Converse County, Wyoming (Fig. 1). It lies on the southwestern margin of the Powder River Basin and within the drainage system of the North Platte River, which is located 1-1/3 miles north of the site. The town of Glenrock is located 2 miles east of the site. The site is situated on the east plunge of Big Muddy Anticline, a large east-west trending, doubly plunging, asymetric anticline, approximately 10 miles long. Late Cretaceous rocks are exposed at the surface. The Pierre Shale forms the surface core of the structure and the progressively younger Mesaverde, Lewis and Fox Hills formations successively outcrop, outward from the core. The steep, north flank of the anticline is not exposed, as it is covered by the Quaternary alluvium of the North Platte River valley. Erosion of the late Cretaceous rocks has resulted in the creation of an alternating series of cuestas and valleys, which ring the anticline, in a pattern typical of eroded anticlines in the Rocky Mountain Area. The most prominent cuesta is capped by the Teapot member of the Mesaverde formation.

The site area lies at the base of a north-facing escarpment with a vertical relief of approximately 120 feet. This escarpment is composed of the three members of the Mesaverde formation which strike N. 60° E. and dip 5 degrees to the southeast. The upper Teapot member lies at the top of the bluff. It is an even to cross bedded sandstone, approximately 34 feet thick. It forms a sheer scarp, approximately 35 feet high. This was the ledge over which the buffalo were driven, at the site area. The Teapot is underlain by the Pumpkin Buttes member which is approximately 85 feet thick and is made up of thin, alternating beds of lignitic shale, brown shale, coal, siltstone and sandstone. This member is easily eroded and forms a steep 35-degree slope, with a vertical relief of approximately 87 feet. The underlying Parkman member is a gray, cross-bedded sandstone over 60 feet thick. The top of the Parkman forms a break in the slope of the

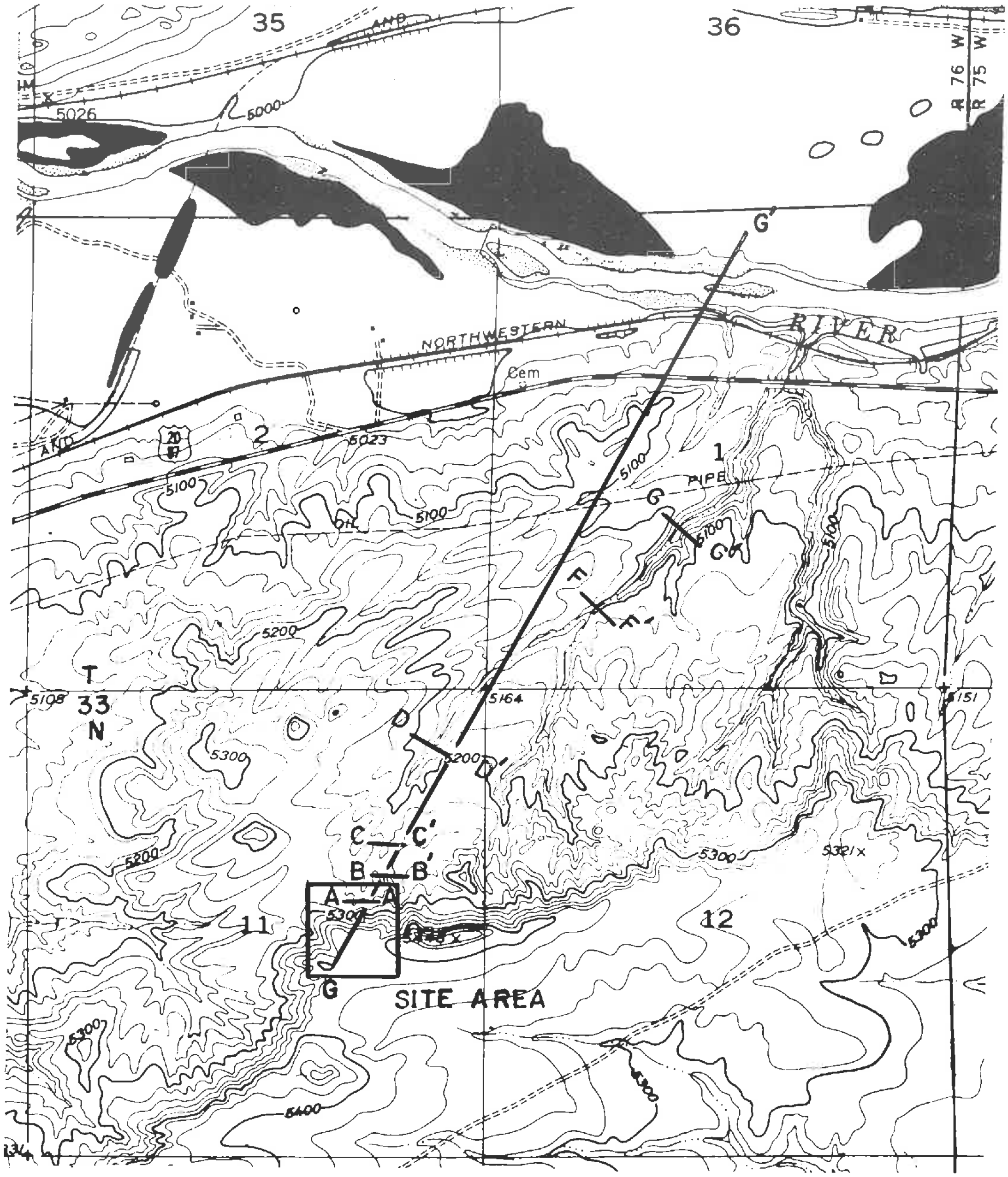

Figure 1 - Location and topographic map of Glenrock Site, Wyoming.

escarpment. Here the slope flattens from 35 degrees to 6 degrees. Most of the excavated portion of the site is underlain by the Parkman member of the Mesaverde.

The Lewis formation conformably overlies the Mesaverde and is composed of gray shale with some interbedded sandstone. The top of the Lewis forms a long gentle dip slope which slopes 3 degrees to the southeast, toward Deer Creek. It is on this slope that the drive lines are located that were used in connection with the bison jump at the Glenrock site.

A small patch of conglomerate of Oligocene (?) age is located at the highest point of the escarpment adjacent to the site (Fig. 2). This conglomerate unconformably overlies the Lewis formation and is composed of large cobbles of granite, granite gneiss and hornblende schist. These cobbles were derived from the pre-Cambrian core of the Laramie Mountains located 6 miles to the south. Cobbles have weathered from the conglomerate and are abundant on the surface, in the site area. They were used as artifacts (principally hammerstones) at the kill site.

The site lies in a gentle, amphitheater-like, topographic depression located at the foot of the escarpment (Fig. 1). This depression forms the head of a small intermittent stream that drains northeastward 1-1/3 miles into the North Platte River. This drainage is incised into the highest and largest Quaternary fill terrace that flanks the North Platte River. This terrace partially covers some of the underlying Mesaverde formation.

QUATERNARY GEOLOGY

Stratigraphy

Two post glacial, Quaternary units can be recognized at and adjacent to the excavated portion of the site. They are the units in which the site material is enclosed and a younger unit which outcrops 500 feet north of the site. Both units are post altithermal in age and were probably deposited within the past 800 years. For convenience in discussion, the older unit will be called Unit Q in this paper. This term has no outside stratigraphic connotation. The younger unit correlates with the Lightning formation of Leopold and Miller (1954). Both units are composed of slope wash material locally derived from the Mesaverde, Lewis, and Oligocene (?) formations that out crop at and adjacent to the site. Both units were measured and sampled. Rock samples were taken every 6 inches or less and were examined under a binocular microscope.

Unit Q

Unit Q has an observed maximum thickness of 14 feet at the site area. It thickens northward toward the North Platte River, but no attempt was made to study this unit in detail outside the site area. This unit is composed predominantly of sand with some lenticular lenses of conglomerate, composed primarily of sedimentary rock debris. Bedding

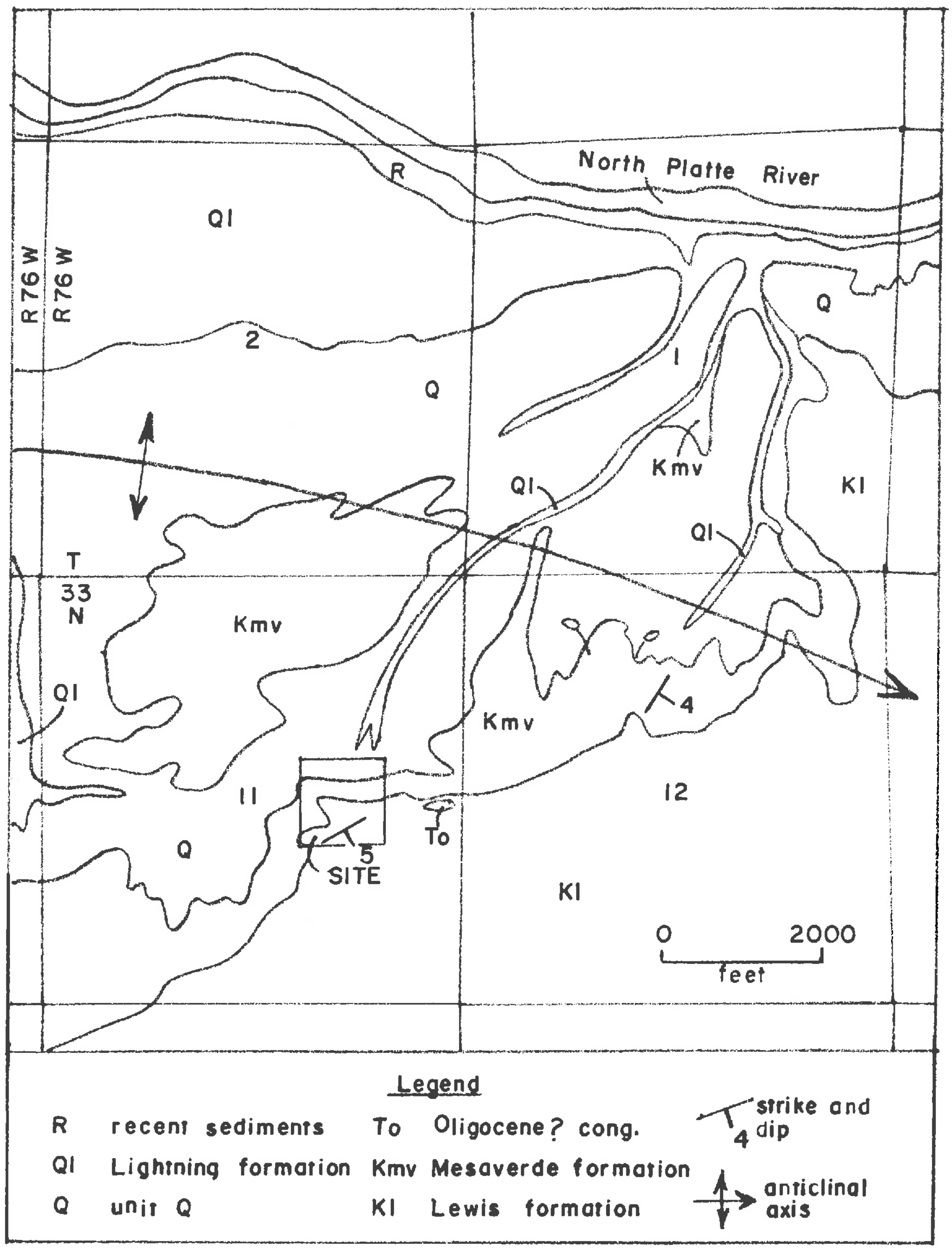

Figure 2 - Geologic map of Glenrock Site, Wyoming

is even, thin, slightly undulating and lenticular. Cross bedding was not observed. A distinctive feature of the unit is the prominent presence of earthy gypsum which was emplaced along grass root fibers by capillary action. All gradations from slightly gypsum impregnated root fibers to a completely replaced dendritic network of gypsum tubules can be observed. The gypsum appears to have been introduced by percolating ground waters and the process is apparently still taking place. The sand in Unit Q is generally noncalcareous though some portions will react with acid due to included bison bone fragments. Bison bones and bone fragments are abundant. When viewing bone layers, in cross section in the excavated trenches, it is sometimes difficult to tell whether they represent cultural levels or have been merely washed in.

Another common feature in the sediments of Unit Q is the presence of maggot cases which are usually localized along certain layers. In most cases they appear to have been washed in and distributed along bedding planes. Their great abundance would lead one to infer that flies were literally covering the area during and after the butchering of the bison. Their preservation would require rapid burial not too long after their creation, as the maggot cases are delicate and subject to rapid deterioration.

Chenopodium seeds are also abundant in some sedimentary layers. This weed, commonly called lambsquarter, is an invader species and generally grows in areas where the soil has been disturbed, usually by animal activity. Frison (1970) has made the observation that lambsquarter, as well as other annual weeds, are still observable at the surface of the Kobold site, a post altithermal bison jump site in Montana. Lambsquarter and other annual weeds are not presently conspicuous at the Glenrock site, though the abundant Chenopodium seeds in the sediments undoubtedly reflects the soil disturbance following the "bison jumps" and subsequent butchering activity.

Other details concerning the lithology of Unit Q are shown in Table 1 in the appendix.

Unit Q can be divided into 3 sub-units,herein called from oldest to youngest, Q_1 Q_2 and Q_3. The oldest sub-unit, Q_1, was deposited in an amphitheaterlike depression that was eroded in the Parkman member of the Mesaverde (see Fig. 3). The depression was originally formed by the headward erosion of an intermittent stream, ancestral to the present one. When the site was first used as a bison jump, the "floor" of the jump was bare sandstone rather than the present sediment and soil. The depression was gradually filled in by sediment washing in from the slope above and also by bones and other material resulting from cultural activity. The maximum thickness of Q_1 at the site is 6 feet.

Sub-unit Q_2 represents a gully that was originally incised into sub-unit Q_1 and the underlying Parkman, and subsequently filled with slope wash sediments and archeological material (see Fig. 3). The sub-unit is 13 feet wide and 6 feet deep at its thickest point. It contains 1 to 6 inch lenses of sand and conglomerate with interbedded slabs of sandstone and bison bones. Maggot cases are concentrated in a 1 - 2 inch layer at the base of the unit. Layering is generally parallel to the sides and bottom of the gully. The generally flat bedding of sub-unit Q_1 abuts into the sides of the channel. Artifacts, bison bones and other in situ archeological material were recovered from sub-unit Q_2. Most of the fire-hearths observed at the site were in this sub-unit.

Sub-unit Q_3 is separated from the underlying sub-units by a thin conglomerate zone, herein called Bed B-4. Bed B-4 is composed principally of sandstone slabs derived from the Teapot sandstone capping the cliff above. Some of these slabs are over 3 feet in length. This is the only sedimentary bed that is present over the entire site area and it was probably deposited during a period of violent cloudburst, when slabs of sandstone were washed down the slope from the overhanging Teapot sandstone. This unit can be traced up the face of the escarpment where it rests directly on bedrock, at a point 30 feet horizontally from the present Teapot scarp.

Sub-unit Q_3 has a maximum observed thickness of 8 feet and is comprised principally of sand with some conglomerate lenses. It does contain some archeological material but not to the extent of the lower sub-units. For a detailed description of this unit see Table 1 of the appendix.

Radiocarbon dates were secured from 2 levels in Unit Q. A date of A.D. 1760$\pm$ 100 (M2350) was secured from a firehearth at a depth of 6 feet 5 inches from the surface in sub-unit Q_2. A second date of A.D. 1690$\pm$ 100 (M2349) was obtained from a depth of 4 feet 3 inches in the lower part of sub-unit Q_3. Both of these dates appear to be much younger than those derived from the geologic data secured at the site. A further discussion of this problem will be presented in the final portion of this paper.

Lightning Formation

Approximately 500 feet northeast of the excavated portion of the site, a sequence of sand and conglomerate is exposed in the bottom of the aforementioned intermittent drainage that heads in the site area. This unit was deposited in an arroyo that was formed in post Unit Q time. The walls of the former arroyo cut through the sediments of Unit Q (Fig. 4). After the erosion, the eroded depression was filled with slope wash sediments which correlate with the Lightning formation of Leopold and Miller (1954).

The maximum observed thickness of the Lightning formation is 13 feet, but the base is not exposed and the formation is undoubtedly thicker. The Lightning formation differs from Unit Q in several ways. The most pronounced is the much greater proportion of conglomerate composed of sedimentary debris present in the Lightning formation. Up to 50% of the Lightning formation may be conglomerate; whereas in Unit Q, conglomerate rarely constitutes more than 15% of the unit. Pre-Cambrian rock fragments are rare in conglomerates of Unit Q, but they are very common to abundant in some conglomerate lenses of the Lightning formation. The earthy gypsum tubules that are abundant in Unit Q are present, but rare in the Lightning formation. The sand portion of the Lightning

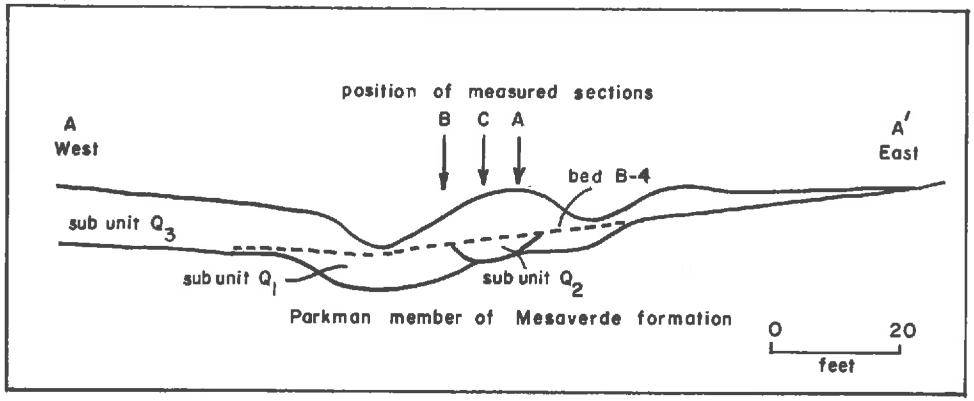

Figure 3 - Stratigraphic Cross Section A-A[1]

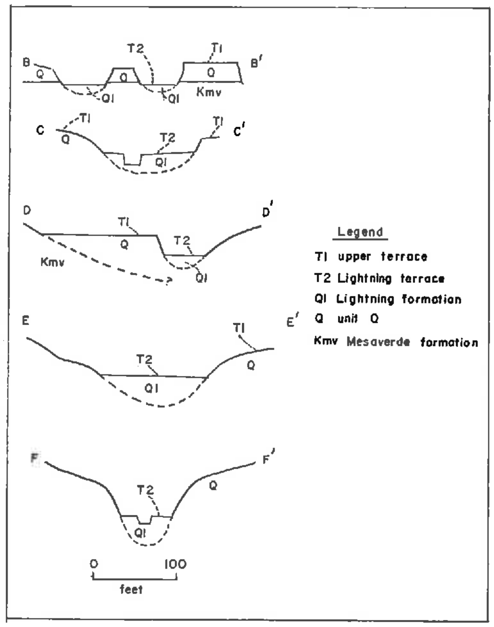

Figure 4 - Cross Sections along intermittent stream.

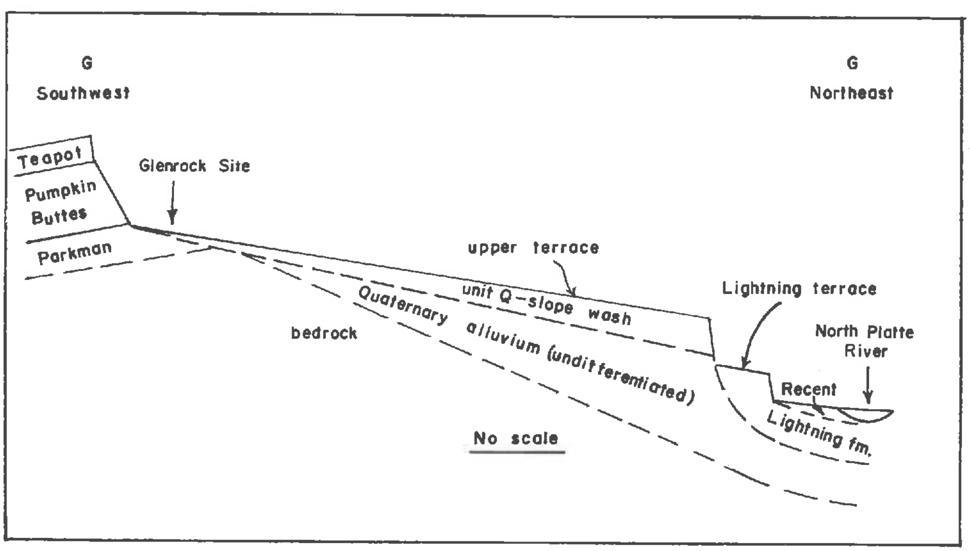

Figure 5 - Diagrammatic Cross Section G-G[1]

formation is characteristically thin and even bedded, as in Unit Q; however, the conglomerate lenses tend to be much thicker and may exceed 1-1/2 feet in thickness. These conglomerate lenses are flat bedded and rarely more than 10 feet long. Cross bedding was not observed in the Lightning formation. An interesting feature of the Lightning formation is the presence of bone fragments and bone particles intermixed with the sedimentary debris in some conglomerate lenses. These bone fragments are generally too small to be identified; however an occasional larger piece such as a tooth or horn core can be identified as Bison bison. This bone material is clearly reworked and was deposited in the Lightning formation conglomerate lenses by water action. It was undoubtedly derived from Unit Q immediately to the south and upstream. This evidence plus stratigraphic position clearly indicate that the Lightning formation is younger than Unit Q. No archeological material was noted in the Lightning formation nor were there any maggot cases or Chenopodium seeds as commonly found in Unit Q.

Quarternary History and Conclusion

A post-glacial, post-altithermal, two terrace system is present along most of the North Platte River valley in Wyoming (Leopold and Miller 1954). These terraces are present in the vicinity of the Glenrock site. The lower terrace lies 5 to 10 feet above the present flood plain of the river. The upper terrace surface lies approximately 40 feet above the river. Both of these terraces are fill terraces. The lower terrace correlates with the Lighning terrace described by Leopold and Miller (1954) as present over most of eastern Wyoming. The top of this terrace coincides with the top of the Lightning formation and can be traced directly into the Glenrock site area (Figs. 1 and 4). The upper terrace probably correlates with the Kaycee terrace of Leopold and Miller (1954), the type locality of which is located along the Powder River in the vicinity of Kaycee, Wyoming. Leopold and Miller did not attempt to directly correlate terraces between the North Platte and Powder River drainages. Haynes (1966) on the basis of radiocarbon dating, would date the top of the Kaycee formation, which corresponds to the top of the Kaycee terrace, as being approximately 3000 years old. A radiocarbon date is not available for the material composing the upper terrace of the North Platte River; however, the local abundance of late middle period artifacts and campgrounds on top of this upper terrace along the North Platte River in central Wyoming would place its formation at least prior to 1500 years ago, and probably much older. Late middle period artifacts are also present on top of the Kaycee terrace along the Powder River.

Leopold and Miller (1954) describe the common occurrence of slope wash material that was deposited on top of the Kaycee terrace after its formation. There is obviously a similar situation at the Glenrock site, where the slope wash material of Unit Q has effectively covered and masked the older sediments which constituted the original fill material of the upper terrace. This situation is illustrated in Figure 5. These older sediments were not observed in any of the gullies in the area; however, exposures are generally masked by recent wash and they may not have been detected.

The post-altithermal chronology in the general Glenrock site area is as follows:

1. Deposition of alluvium which constitued the fill for the upper North Platte River terrace.

2. A period of moderate erosion which resulted in the cutting of drainages into the old fill surface. The original "amphitheater-like" erosional depression at the site was formed in the Parkman sandstone at this time.

3. Deposition of Unit Q.

4. A period of major erosion and downcutting. The scarp which forms the riser for the upper terrace of the North Platte River was formed at this time. Tributary drainages of the North Platte River were deepened and a system of deep arroyos and valleys were formed. This episode of major erosion is readily recognizable over all of the Powder River Basin. Many of the prominent arroyo walls discernable over much of eastern Wyoming were formed at this time. A prominent example of this erosion in the central Powder River Basin has been described by Albanese (1971). Downcutting along the North Platte River amounted to at least 50 feet and may have been greater in places.

5. Deposition of the Lightning formation.

6. Downcutting and erosion which began between 1880 and 1900 A.D. and has continued uninterrupted to the present time. Downcutting adjacent to the site has exceeded 15 feet in places. It increases with every rainstorm.

Leopold and Miller (1954) believed that deposition of the Lightning formation began in eastern Wyoming between A.D. 1200 and A.D. 1500. These estimates were based on stratigraphic correlations with formations in the southwestern United States. Unfortunately definite confirmation of these dates by radiocarbon or other means is lacking. Also lacking is a definite date for the erosional period, immediately preceding the deposition of the Lightning formation. If the radiocarbon dates of A.D. 1690 and A.D. 1760, secured from Unit Q are accurate, it means that deposition of the Lightning formation and the prior period of erosion, took place between A.D. 1760 and A.D. 1900, a period of 140 years. The Lightning formation underlies extensive areas of the North Platte River valley. If its deposition and prior erosion sufficient to cut 40 foot cliffs, all took place in 140 years, it would seem that some accounts of prolonged and extensive flooding and deposition should appear in the historical records; particularly as the North Platte River valley was part of the main route of the Oregon Trail. As far as the author is aware, historical research has not been conducted along these lines. It seems more reasonable to accept the age estimates of Leopold and Miller. If they are correct, it would necessitate a minimum age for the Glenrock site of between 450 and 750 years.

TABLE 1 . STRATIGRAPHY OF THE GLENROCK SITE, CONVERSE COUNTY, WYOMING

Sections A, B, and C were measured along excavated trench 45-50. Their exact location is shown in Figure 2. Sections D and E were measured along the intermittent drainage that originates at the site and flows north-eastward. Measured section D is located 550 feet northeast of trench 45-50 and section E was measured 600 feet northeast of trench 45-50.

Sub Unit	Bed	Measured Section A Section starts at surface and is measured downward.	Thickness in Feet
	1	Modern soil zone composed of sand, light tan, fine grained, argillaceous, very abundant root fibers which comprise 10% of the bed; some gray shale, coal and lignitic shale fragments; trace of bone fragments.	0.60
	2	Sand, light tan, fine grained, argillaceous, abundant root fibers, some earthy gypsum tubules; abundant root molds in upper 9 inches; sand contains 1 to 4 inch layers of gravel composed of gray siltstone, gray shale, coal and lignitic shale; bedding is flat; sand is silty and contains abundant gray chert grains in lower 9 inches of bed; a few Bison bison bones are present along some layers.	2.25
	3	Interbedded gravel and sand lenses; scattered Bison bison bones along some layers; sand is light tan, fine grained, argillaceous and contains root fibers and abundant earthy gypsum tubules.	0.66
Q_3	4	Sand with scattered, interbedded gravel lenses ranging from 1 to 2 inches in thickness; gravel comprises 15% of bed; white, earthy gypsum tubules and fibers (1/4 to 1 inch long) are very abundant with an average density of 10 per square inch; sand is light tan, fine grained and contains abundant grass root fibers, root molds, bone fragments and scattered Chenopodium seeds; the conglomerate is composed of lignitic shale and some coal fragments.	1.75
	5	Sand, light tan, fine grained, argillaceous, finely layered upper portion contains scattered coarse grain size to 1/8 inch long fragments of shale, siltstone and coal; root fibers are abundant and show all gradations from unaltered plant fiber to white earthy gypsum, the solutions containing the calcium sulphate seeped along the roots by capillary action and gradually replaced the plant material. Chenopodium seeds are very abundant, particularly in the lower half of the bed; large Bison bison bones are scattered along layers in the lower 9 inches of the bed; small bone fragments ranging from very fine	1.20

grain size to 1/4 inch are scattered throughout the bed; a 1 inch gravel layer at the bottom of the bed correlates with bed B-4.

Total thickness of sub unit Q_3 is 6.5 feet.

Measured Section B

Section starts at surface and is measured downward.

1 Sand, light tan, fine grained, very argillaceous, slightly micaceous, abundant root fibers; abundant earthy gypsum "fibers"; some 1 to 4 inch lenses of gray shale and lignitic shale particles (1/8 to 1/4 inch long). 1.20

2 Sand, light tan, fine grained, highly argillaceous, some scattered light gray and orange shale fragments (1/8 inch long), slightly micaceous; some root fibers; some white earthy gypsum "fibers"; scattered interbedded Bison bison

Q_3 bones; trace of gray chert artifact chips; bed is generally massive with a few 1/2 inch layers. 0.66

3 Sand, light tan, fine to medium grained, argillaceous, some scattered fine grain size, rounded, light gray, chert grains; numerous maggot cases; intermixed Bison bison bone fragments scattered 1/8 to 1/2 inch long fragments of light orange and rust colored siltstone and gray lignitic shale; scattered white, earthy gypsum tubules; some wood fragments; some 1/8 inch artifact chips of light orange, gray and yellow chert; contains few grass stems. 0.33

4 Sand, light tan, fine grained, argillaceous, silty with intermixed 1 to 2 inch sandstone fragments; abundant root fibers coated with earthy gypsum; abundant root molds; some laminae with root fibers parallel to bedding - this bed (B-4) marks the base of Unit Q_3. 0.45

Total thickness of sub unit Q_3 is 2.6 feet.

5 Sand, light tan, fine grained, slightly argillaceous, slightly micaceous, prominent fine grain size, sub-rounded, gray chert grains; sand is thinly layered with 1/4 to 1 inch interbeds; some 1 to 2 inch thick lenses of conglomerate are present; they are composed of 1/4 to 1/2 inch fragments of lignite, gray lignitic shale, light gray shale and light yellow siltstone; root shaped tubules of white earthy gypsum are present throughout the bed with a density of 4 to 5 per square inch; a few isolated Bison bison bones are scattered throughout the bed; scattered maggot cases are common in lower half of bed; Chenopodium seeds are common as well as wood fragments; a

Q_1 few light gray chert artifact chips were noted in the upper half of the bed. 1.80

6 Bed is composed of 1 - 2 inch alternating layers of sand, light tan, fine grained, slightly calcareous, slightly argillaceous,

slightly micaceous (muscovite) and conglomerate composed of 1/8 to 1/3 inch fragments of orange siltstone, light gray shale, coal and sandstone in sand matrix; scattered, loose, fine grain, sub rounded, gray chert grains are very common; the bottom 6 inches of the bed has fine, 1/8 inch layering.

7 Conglomerate composed of 1/8 to 1/4 inch fragments of orange, sandy siltstone; light gray, argillaceous siltstone; coal and gray lignitic shale in fine grain size, sand matrix; a few granite fragments are present; a few light orange chert artifact chips were noted.

Total thickness of sub unit Q_1 - 3.66 feet.

Bedrock-Parkman Sandstone

Sandstone, light gray, fine to medium grained, sub-rounded to sub-angular, good sorting, slightly argillaceous, very slightly micaceous (muscovite); prominent black to gray chert grains give the sandstone a prominent "salt and pepper" appearance; sandstone is very friable and has some slight limonite staining.

Measured Section C

Section starts at base of bed B-4 and is measured downward.

Q_2	1	Sand, light tan, fine grained with intermixed angular, gray siltstone fragments and light gray shale fragments; fragments vary from 1/8 to 2 inches in length and constitute 25% of bed; scattered small coal fragments were noted; root fibers are present; white, earthy gypsum "fibers" are very abundant and range from 4 to 10 per square inch.	0.50
	2	Sand, light tan, fine grained, argillaceous with some intermixed siltstone and coal fragments; earthy gypsum "tubules" are present; contains prominent wood fragments; contains intermixed bison bones; gravel lens at base.	0.75
	3	Sand, light tan, fine grained, finely layered; contains some conglomerate lenses; contains numerous bison bones, layering cuts across bones; contains some large sandstone slabs that lie parallel to the bedding.	0.75
	4	Alternating thin layers of sand, light tan, fine grained with rounded, gray chert grains and some conglomerate lenses composed of orange and light gray shale fragments; abundant coarse grain size orange feldspar and granite grains; some bone fragments; scattered sandstone slabs are interbedded in sequence; a 2 inch layer composed of intermixed sand and maggot cases lies at the very base of the bed.	0.75

Total thickness of sub unit Q_2 is 2.75 feet.

Bedrock - Parkman Sandstone

Measured Section D

Section starts at surface and is measured downward.

1 Sand, light tan, fine grained, fair sorting, abundant scattered gray chert grains, slightly argillaceous and silty, some scattered coal grains; some coarse grain size, sub rounded, siltstone fragments; scattered root fibers and root molds; sand is thin bedded and even bedded with a few interbedded conglomerate lenses which vary from 1 to 2 inches in thickness. Conglomerate is predominently sedimentary rock fragments of brown and red siltstone with some sandstone, gray shale and granite fragments; fragments vary from 1/4 to 1/2 inch in length and are sub angular in shape. 6.0

2 Conglomerate, composed of sub angular sedimentary rock fragments 1/4 to 4 inches in length; fragments consist of sandstone, brown and orange siltstone and gray shale; matrix is composed of fine grained sand with some included coal grains and fragments; bed contained some intermixed bone fragments and a horn core of Bison bison. 1.60

3 Sand, light tan, fine grained, fair sorting with prominent, scattered dark gray chert grains; contains some root fibers and root molds plus scattered coarse grain size, rounded fragments of siltstone, gray shale, lignitic shale and coal; bed is thin bedded. 1.0

Total thickness - 8.60 feet.

Above sequence is the Lightning formation. The base of the unit is not exposed.

Measured Section E

Section starts at surface and is measured downward.

1 Sand, light tan, semi-consolidated, fine grained, subrounded, fair to poor sorting, thin bedded, silty and argillaceous streaks; contains abundant fine to coarse grain size, coal inclusions and abundant root and wood fibers, some root fibers are parallel to bedding; root molds are common; dark gray, fine grain size chert grains are abundant; sand contains thin (1 - 2 inch) interbedded lenses of conglomerate composed of 1/8 to 1/2 inch, fragments of red and orange siltstone plus some sandstone. Bed is generally even and thin bedded. 8.33

2 Conglomerate, composed of 1 - 2 inch long, sub rounded fragments of orange and brown siltstone, sandstone, gray shale and coal; matrix composed of fine grained sand with scattered root fibers. 0.45

3 Sand, conglomeritic, tan, fine to medium grain size with trace of scattered, fine grain size bone fragments; scattered throughout sand are 1/4 to 2 inch, sub rounded fragments of sandstone, orange and brown siltstone, gray shale and 1/8 inch, sub rounded grains of granite; bed contains scattered root fibers. 0.65

4	Conglomerate as in bed 2; some included bone fragments up to 1/2 inch long.	1.25
5	Sand, light tan, fine grained, sub rounded; some scattered, 1/4 inch, sub rounded fragments of orange and red siltstone and sandstone; fine grained size sub rounded chert grains are abundant; some fine grain size, sub-rounded bone fragments.	0.33
6	Conglomerate, composed of abundant, thin sandstone fragments, 1/2 to 1-1/2 inches long plus some sub-rounded fragments of sandstone and siltstone which vary from 1/8 to 1 inch in length; coal flakes are numerous; a few bone fragments and a tooth of Bison bison were noted; matrix is composed of fine grained sand.	0.65
7	Sand, light tan, fine to medium grained, sub-rounded, numerous fine to coarse grain size fragments of coal; abundant fine grain size, gray chert grains; bed slightly argillaceous; some scattered root fibers and root molds.	1.0

Total thickness - 12.66 feet.

Above unit is the Lightning formation. It is even bedded. The base is not exposed.

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